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A Course of Lectures on the Theory and Practice of Chemistry

by

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Introduction

I have once more the honour of appearing before you in order to deliver a course of Lectures upon the Theory & Practice of Chemistry — I shall beg leave to take up your attention at this time, while I endeavour to point out the Nature, the Objects & uses of this Science —

The Votaries of all sciences are fond of giving them as much Dignity as possible, by tracing their origin back to some remote period of Time — Chemistry has had its Votaries of this kind, who have endeavoured to perswade mankind, that the origin of their Science was coeval with that of the world itself. Hence we are often told that Noah who employed himself in making Wine soon after the Flood, & Tubal Cain who was descended so nearly from Adam, were both expert Chemists — But we are to distinguish between those times, in which

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which the Principles of Practice of an Art, are introduced into the World; for altho' the art of making Wine, & the Art of making Brass, together with many, which are connected with Chemistry, subsisted in the earliest Ages of the World, yet the practisers of them were entirely ignorant of any Principles of Chemistry. —

It is not my Design to enter into those trifling disputes, which have been carried on among Chemists concerning the Antiquity of their Science. In my Opinion it will not detract in the least from its merits to say, that instead of being the most ancient it is the most modern of all Sciences —

In this Respect it is on a footing with Astronomy, Navigation & Electricity, which tho' modern sciences have always been looked upon, among the most perfect & useful of them that ever engaged the attention of Phylosophers —

It might afford some satisfaction to enquire

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into the Causes which have retarded the progress of this Science. In general we may observe, that most of the Objects of Chemistry, are buried in the Bowels of the earth which 'till of late have been but little searched into by the enquirers after Knowledge. The Rudeness of form which we observe in all fossil substances & the seeming resemblance they have to each other, made it difficult to distinguish them by any certain marks, without subjecting them to many experiments which however useful, in making discoveries was little practised by the Philosophers of former Ages. Add to this, that what little knowledge prevailed among them was confined to illustrious Men, who valued every thing they found out, so highly as never to communicate it, if they did it was at such a price, & upon such conditions as to prevent its becoming publickly known & useful to the World. —

The Objects of Chemistry are wide & various, — every compound substance in nature, every thing in the Sea

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Sea, or the surface, or in the Bowels of the Earth & in the Air, are the objects of Chemistry. — Here it may not be improper to introduce a distinction between a Chemical & Mechanical Philosophy. — The latter is concerned, in concidering chiefly the Properties of Bodies. Whereas the former is employed only in considering the Effects of heat & mixture in order to find out the particular properties of Bodies. Thus in treating upon the Air ~~the Air~~, the Mechanical Philosophers speak only of it Density & Rarity — of its sensible Qualities — of it's wieght & space oc=cupied by a certain Quantity of it, Whereas the Chemical Philosopher omitting all these Qualities only enquires whe=ther it is a simple or compound Body. — if compound he endeavours to find out what matters inter into its Composition — & in what proportion & by what means it is suspended or mixed with it. In this manner he pro=ceeds in his enquiries into the Nature of Water — Earths Metals & all the other objects of Chemistry —

Let us now enquire into the uses of this science —

It is from its nature conversant with the Works of God; which are always full of entertainment, & designed to answer some valuable purposes. His wisdom often appears most Conspicuous in the lowest of his Works; some I know pretend to hold this kind of knowledge Cheap as being employed only in considering the minutiæ of nature. To this we answer that every thing that God had made deserves our notice. What an affront to an Architect would it be, if a man was ~~conducted~~ introduced into a newly finished Palace, should he only admire the Grandeur of the Arches, or the Majesty of the Pillars, & pass by the nice execution of the several orders of Architecture. The Dial Plate of a watch is certainly very beautiful, but what is it when compared with the excellent workmanship of the inside, upon which every beaty of the outside depends. But its importance will appear most when we enquire a little into its uses

And 1.st Every body is sensible how useful Chemistry is in Physic. Formerly it was considered as a branch of Medicine

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Medicine, & defined as such at present, it is only applyed to it in common with many of the Arts. A knowledge of Chemistry is indispensably necessary to a Physician. It is impossible to make ourselves acquainted with the nature & laws of the Animal Oeconomy without it. It is by means of this science that we can arrive to any knowledge of the fluids of the Body. This part of animal Phisiology, has long laboured under many difficulties. Many Salts & Chemical substances were supposed to reside in our fluids which modern experiments on the nature of these sub=stances out of the Body convince us, never had any exis=:tence there _ Acids & Alkaline Salts with all the train of diseases consequent upon them are now exploded from the Body & the Phænomina which lead us to such Theories are now solved upon more simple & rational principles —

Many enquiries have been made into the Causes of animal -heat_ Many things in the Animal Oeconomy might be explained could we arrive at the knowledge of it, but may not Chemistry give us some light in this matter? We shall

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shall perhaps show hereafter, that it has already assisted us considerably in our researches into this subject —

Digestion that wonderful Operation in the human stomach, has been proved to be carried on by a Chemical Process; Animal secretion has long puzzled our ablest Physiologists, but it is not analogous to many Chemical Operations & may not an accurate investigation of the principals of Chemistry lead us to some useful Conclusions upon this head — The light which Chemistry afforded us in the formation of pus gives us reason to expect something from this Quarter — In Pathology chemistry promises us still more success, most of the Potentiæ nocentes (as they are called) are objects of Chemistry. How many diseases depend upon the quantity of Air, & how much are they influenced by mixture with foreign substances! Many diseases we see are produced by Contagion, which some suppose acts in the same manner as ferments do out of the Body. By inquiring into the nature of Fermentation

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we may perhaps find out an analogy between it, & the process which goes forward in the human Body in contagious Diseases. The ~~Formentation~~ of stone & extraneous matter in the Body has been accounted for by Chemistry. May not the same science in time furnish us with means of dissolving these foreign substances, & thereby of removing them out of the Body? But further how many tradesmen ~~are~~ there are subject to particular Diseases from the nature of their occupations or the materials they work in. The Plumber labours under the cholic. The painter is afflicted with a train of nervous Diseases. The soap maker. — The Brasier — The Minor, — the workers in Glass — China — & all different kinds of Clay, have all their peculiar Disorders, which are only to be found out & cured by an accurate Knowledge of the properties of their materials, & these are for the most part objects of Chemistry. How many drinks contain in them the seeds of disorders, which nothing but a knowledge of the principles of Chemistry can unfold or Cure. — Dr.

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Dr. Baker has lately led us to a new cause of the Devon=
=shire Cholic, & has proved that it depends, (at least in
some measure) upon the great quantity of Cyder drank
in that place, which he informs us all-ways runs thro'
leaden Pipes. Sometime ago an epidemic Cholic was obser=
=ved in this City of Amsterdam, many attempts were made
to find out the cause of it, but to no purpose. An eminent
Physician who was an able Chemist being consulted about
it, observed that the houses in Amsterdam were, at that
time, covered with lead, & that a number of Trees grew be=
=fore the Doors of most of them. In the Autumn, the lea=
=ves of the Trees falling upon the Roof of the Houses, under=
=went a Fermentation, which produced a Vinegar, capable
of corroding lead. The Water which run across the lead
carried away certain Parts of it, which being used in
Diet he found produced the Cholic. After this Tiles were
made use of to cover their houses instead of lead, & the cho=
=lic never afterwards was heard of among them. The Proper=
=ties of heat could come likewise under the notice of Chemistry.
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We need not say how far they influence Diseases. No man can pretend to read a book upon Medicine, with advantage without being well acquainted with the nature of the climate in which it was wrote, much less can he pretend by his Operations upon Diseases without being well acquainted with the nature of the Climate in which ~~it was wrote, much less~~ he lives.—

With regard to the <u>Dietetic</u> part of medicine, Chemistry is of the highest use, a proper Diet is of the utmost importance in Physic. Without it few medicines will produce their effects, & without it medicines oftentimes become entirely unnecessary. Why should new Wine disorder the Bowels & not old? Why should Vegetable food encrease some, & remove other Diseases? What constitutes the various kinds of Fruits— milk —& flesh? Why are some suited to particular Diseases & hurtful to others? Why is old flesh, (however strange it may sound) I say why is old flesh more easily digested than young? Why does mixing certain

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-tain aliments in the stomach produce such a variety of complaints? Why is our Diet to be influenced so much by the different seasons of the Year? Why is flesh so insipid to us without bread of somekind? Why are malt liquors to be preferred to Water? Why are Wines of the North so much better than those of the South in particular disor=ders? All those Questions & many others which belong to Diet are easily resolved by Chemistry —

I would not however be understood to say that all the Functions of the Body of which we have been speaking are carried on in a manner perfectly analogous to those Things, which resemble them out of the body, or that re=mote causes produce exactly such Effects upon the body, as by reasoning a priori, we should be induced to believe. — The Animal Body is an animated machine, endowed with sensibility, & irritability, which distinguish it from any other kind of matter. The Opperations of dead mat-ter upon dead matter, may be reduced to certain Laws. But

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But the Operations of dead matter in living, are always carried on in a manner peculiar to themselves, & cannot well be illustrated by Analogies, borrowed from other parts of Nature. Many Errors have arrisen in medicine, from applying the principels of Chemistry too generally to it. Physic still groans under many of them. Mathematics for a while produced the same evil, but the evil was removed by the Mathematics themselves afterwards; in the same manner later improvements in Chemistry daily remove Errors in Medicine & if we would wish to ascertain the ~~true~~ exact limits of our Knowledge in Physic, Chemistry must be our guide in our researches. But to return —

Chemistry is principally of use to the Physician, as it furnishes him with most of the medicines employed in the Practice of Physic — It is by means of these, that Chemistry has taught him that he learns to convert the most deadly poisons into useful Remedies. It is by means of these that he prepares & compounds his medicines properly, without decomposing them, & thereby rende=ring

-ring them ineffectual, or what is worse producing compounds which the prescriber never intended. There is scarce a disease the human Body is subject to but what has an Antidote in the mineral Kingdom. The Small Pox we find has been rendered mild by pre-parations of Mercury. Tart Emetic is almost a Specific in the cure of fevers, when administred in certain Stages of them, & in proper Doses, in a word, Antimony - Lead, Cop-per - Tin & Iron have all their uses in medicine when prepared & administred properly - The mineral waters abound with healing Virtues. Nothing but a knowledge in Chemistry can inform us when, & in what doses to pres-cribe them, as it is by Chemistry alone we come to a know ledge of what they contain. I know there are some who declaim against all kinds of Chemical Medicines, & en-deavour to confine us entirely to Plants, which they say was made by the Creator of the World, on purpose to be used in

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in Medicine, & upon this account are distributed so plen-
-tifully all over the ~~earth~~ surface of the Earth. Far be it
from me to descry Galenical Medicines. They are equally
useful with the Chemical ones - But I would beg leave to
ask those Gentlemen who urge this objection against
Chemical Medicines, who it was formed the minerals in
the Bowels of the Earth? & for what purpose? -

Did not the same hand which planted the Poppy, &
endowed the Peruvian Bark with such wonderful proper-
-ties, pour four forth its ~~properties~~ Treasures into the heart
of the Earth? Besides they are both of them alike objects of
Chemistry; for there is scarce a vegetable medicine in the
World, but what requires as many operations of Chemis-
-try, as most of the metallic substances do, in order to prepare
it to be exhibited with safety or advantage. - But
2.ly Medicine is but one of those sciences to which Chemis-
-try is applicable, next to the Physician the natural his-
-torian receives great Benefit from this science -

As Natural History is the Foundation of Chemis-
-try

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:try, so Chemistry is a considerable Pillar in natural history. Every Complaint of the imperfections of that part of this science relates to fossils. A Principle Reason of this may be owing to natural historians being ignorant of the principles & Operations of Chemistry. How many substances of the most opposite nature resemble each other. Most of the metals are combined with Sulphur & Arsenic, that it is impossible to dis:tinguish them by their sensible properties — Crystals - Spars & all the different kinds of Clays, are each of them liable to the same ambiguity, & stand as much in need of the acids in Chemistry. But by means of the assistance which the Furnace & the Forge together with a few of the Acid Spirits lend us, we may analyze them, so as to find out their na:ture & principles, & afterwards reduce them to their proper Classes — Orders - Genera - but again —

3^ly^ Most of the Metallurists owe the perfection of their Arts in some measure to Chemistry. I would beg leave here to extend the meaning of the word Metalurgy & to include in it all those Arts which are concerned in working

upon

upon metals, the Delusions of the Alchemists have long made the metals the more immediate objects of Chemistry; insomuch that Homberg has defined Chemistry to be nothing else but the "art of resolving & compounding minerals by means of fire"; animated with the love of Gold, they have torn open the Bowels of the Earth & subjected every thing in it to a thousand experiments. Analogies have been borrowed from every part of Nature, particularly from the Changes which Vegetables undergo to support their Visionary notions, & even Religion itself has been made subservient to the Discoveries they aimed to make. Nothing could be more absurd than the researches of these deluded Men, & none but persons entirely ignorant of all true principles in Philosophy, would have ever engaged in them. They mistook the very nature of Gold, in supposing it to be the perfection of metals, & they belied Nature, in imagining that she always aimed at procuring this perfection. Iron is certainly a more perfect metal than gold, & is

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is subservient to many more uses in life. Besides they forget that the value of money depended on its scarceness, & that an art to convert the baser metals into it would de=feat the Designs of providence in making it the medium of Commerce in all Ages & in all countries. Had they ap=plied their discoveries sooner towards improving Arts & ma=nufactories, they would have found out the true Philoso=phers-stone, & converted even the basest materials in na=ture into Gold. As the fruitless attempts which have been made to find out a North west passage into the South Sea or Pacific Ocean, have led to some considerable Discoveries in Geography — so in like manner, notwith=standing the Absurdity of the dreams of the Alchemists, they have enriched Chemistry with a great Variety of useful facts, & pointed out methods of working upon most of the metals, which have been applied to many of the most important, & useful purposes of life. This leads us in the

4th place to take Notice that Chemistry contains in its

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its Principles of most manufactures, & that there is scarcely one of them but what has or may be improved by it; Was I not affraid of exceeding the ordinary bounds of a Lecture I might here point out a few of those Arts which have been most indebted to Chemistry; mention the Brewer - The Distiller - the Sugar-Baker - the Dyer — the Bleacher - the Painter - the Soap-boiler the Powder-maker & the Brazier - the Tanner - the Varnisher - the Enameller & the Jeweller - the Glass-maker & all the workers in ~~Clate~~ Clay from Paste & Porceline down to the most common Earths, are as vouchers of the usefulness of Chemistry. I might further show what assistance it is capable of affording, in that most important of all sciences, Agriculture. By this the husbandmen may learn how to distinguish, & ascertain the properties of the Loam — Marl - Sand & Clays, which his soil contains, & to know which of them is most proper for the different Grains he intends to raise - By this Science he may learn the Nature & application

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application of Manures, & thus render his most barren Heaths fertile, & proper for use. — A proper attention to these things is highly incumbent upon us all, at the present Juncture when the situation of our coun-try, calls upon us to attempt y cultivation of Vines-hemp & many other things, which we see grow in parallel Latitudes & which we are sure would tend to enrich & make us a free & powerfull people —

From this history of the nature & application of Chemistry it will appear, that it is a study no ways unworthy Gentlemen of all Ranks & by no means confined to the Physician alone. If our Studies are influenced by the entertainment, they afford us, then no study should Chalange more Votaries than Che-mistry. Here the young mind may easily be deliv-ered from a thousand Prejudices which inslaves it. — Here Magic, may be disarmed of all its delusive charms. How many Phænomina in Nature, have been attribu-ted to preternatural Causes, which are easily explai-ned by Chemistry upon the most natural & obvious Principles

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Principles – It is by this Science he is enabled to disco-
-ver the Cause of Earthquakes & to admire the Goodness
of the Deity in providing our Earth with so many Volca-
-no's, which serve as so many outlets, for the subterrane-
-ous Matters, which occasion them. By making him-
-self acquainted with the nature of heat, & Evaporation,
he beholds with Pleasure, the Sun performing the of-
-fice of a Sand heat, upon the ocean, & raising fresh Wa-
-ters from it, which are agitated by the Winds here &
there, ~~condensing~~ & afterwards distilled in fertilising
showers upon the Earth. It would be endless to point out
all the operations of Nature, which bear a strict analo-
-gy to the Operations of Chemistry. In a Word Nature
her self is a great Chemist. She has her Elaboratories –
her Furnaces – her stills, her retorts, her Recivers By
means of which She is always employed in carrying in the
great Oeconomy of the World. I grant Chemistry has
been sometimes pushed too far in accounting for Natu-
-al Phænomina. Thus for Instance the Chemist endea-
-voured for a long time to account for Thunder & Light-
-ning

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-ning till our illustrious Countryman Dr. Franklin shew'd it to depend on very different principles. But this Error arose rather from an Ignorance of Chemistry, than from an abuse of it. For the least reflection in the world would have convinced them that the nitrous acid, could never be sufficiently concentrated nor inflammables # so copiously collected in the Air as to prove the Cause of Thunder & Lightning —

One thing I must observe before we finish our account of Chemistry, & that is, that it is an *experimental Science*. *Lord Bacon* justly observed, that it is a great hurt to any Branch of Philosophy, to be brought too soon to a science. Chemistry has enjoyed this Advantage of advancing with slow steps to one, hence we find few sciences in the World abound with more facts than this. Still however we shall find that it is inferior to none of them in Rational philosophical Principles —

Here then, Gentlemen, give me leave to make

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make a Digression from my Subject, or rather an applica-
tion to it. If Chemistry is so fruitful of entertainment, &
capable of being applied to so many useful Purposes, may we
not congratulate ourselves that we were born in a Country, that pro-
mises so fair for being a proper field to study in it? while
most of the Corners of Europe have been ransacked for disco-
veries, we have immense Tracts of Land, open to us, which
never have been trod by the feet of a natural historian.
How many Plants possessed, (for what we know) with medi-
cinal Virtues suited to the Diseases of our Climates, ex-
hale, (to use the Words of the Poets) "their sweetness in the
Desert Air." How many fossil Substances, lie buried in
the Bowels of the Earth, which are capable of enlarging
our Commerce, with~~out~~ other Parts of the World. Copper
Lead & Cobalt are found in great Quantities in this, & the
neighbouring Provinces. Cinnabar & even native Sulphur
have been lately discovered in some parts of new Jersey.
Most of the precious stones are to be met with in the
River Susquehanna. I have now in my possession some
Pieces of

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Pieces of Garnet, which were found in the neighbourhood of this City. An ingenious artist showed me a few days ago a lump of ore dug from a Bank at the north end of this City near the River, which if properly prepared would be equal to the best Spanish Brown. The Materials for making Prussian Blue are all within our power & may be produced at a very small expence. The Clays which are capable of affording Porcelaine are often met with in new Castle County. The Ingredients for making Salt petre abounds more here perhaps than in any Parts of the World. What a Feild then is there open for our improvement? How many Spurs are here offered to us to animate us in our Persuits of literary Fame

"O Fortunati nimirum, si sua Felicia norint
"Americani"— — Virgil.—

Can there be a more laudable passion than the love of Knowledge? Can there be a more honourable Desire than to strive to encrease the Comforts & diminish the Calamities of our fellow Creatures? Who is there here

that

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that does not wish to have his name enrolled with a Bacons, a Boyles, a Bays, a Cullens & a Blacks — America will be the Place where merit will enjoy the greatest reward. The Arts & Sciences have ever been travelling Westward, they began in Egypt & will propably end in America. All-ready they begin to Dawn upon it; what may we not expect when they arive to their meridian Height?

Before I conclude give me leave to congratulate you upon the advantages which you are now possessed off, of becoming perfect in your Profession. I shall say nothing of the merit of our lectures, or of the Qualifications of those Gentlemen, who are are called upon to teach them. Instead of this I shall tell you that much of your improvement will be derived from each other for this purpose I hope you will not fail to go on with that useful Medical Society, which was instituted here last Year. The Advantages of which can only be conceived of by those who have attended it. —

Suffer

a The Art of mixing Gold with water was understood by Moses, the Jewish Legislator who was well skilled in the learning of the Egyptians. —

Suffer me here to reprove a fault to which I am affraid your own Inclinations have led you & (i.e.) a neglect of reading, without this you may attend Lectures for seven Years & even carry home with you correct copies of each of them, & yet will never be able to lay the least claim to the Character of compleat Physicians. A course of lectures upon any Science is no more than an Introduction to that Science — & you might as well think of setting up for compleat Mathematicians after you have read the first six Books of Euclid, or of navigating a Ship after learning a little Arithmetic & Geography, as to think of setting out in your Business with no other foundation than what you have acquired from your professors. Among many other advantages which you will derive from reading Medical Books, I shall mention only one, which to a liberal Spirit will be of great consequence, & that is, it will tend to deliver you from that servile Obedience, which young men are too apt to pay to the Opinions of their Masters, & will make you ~~dare~~ to think ~~Masters~~, for your

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your selves. A step this which never fails paving the way for a mans becoming Eminent in his Profession. —

As for such of you Gentlemen as are engaged in serving Apprenticeships to the several Physicians in this City, permit me to request of you for our sakes, as well as your own, that you would study your respective professors interest so much as not to suffer your attendance upon our lectures to come in competition with it. The more you confine yourselves to their Business, the more you will learn of the true nature & History of Diseases & the more you know of these, the more you will profit by your Lectures & Books. —

In a Word, Gentlemen, let me exhort you to be diligent. Remember the Eyes of the whole City are fixed upon you, they will not fail of determining the Character of your School of Physic from your Conduct. The longest time that any of you have devoted to the study of medicine is short when compared to the extent & Importance of

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of the Science. May I not hope therefore that you will this Winter, shut your selves up entirely from the amuse=
=ments of the Town, & fill up every moment of your time, in acquiring something that will be of use to you hereafter? And as for such Gentlemen, as will not be per=
=swaded to attend their Business "who will neither read or reason, & who intend to practice at random & prescribe by Rote." I would beg leave in the Words of D.r Huxham in his excellent preface to his treatise upon Fevers, to recommend them seriously to peruse the 6.th command=
=ment — — —

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Gentlemen –

In our Introductory Lecture we poin=ted out the Nature, Objects & Uses of Chemistry. The Business of the present lecture shall be to say a few words concerning the history of Chemistry –

This Science like most others, Authors tell us was rocked in its Cradle in Egypt. From whence it traveled ~~into~~ Greece, & afterward to Rome. In each of these coun=tries no doubt Discoveries were made in Chemistry.[a] The application of fire, for the purposes of Operating upon metals likewise took its Rise in Egypt. In Greece Che=mistry made some progress, but was confined to their Preists, who made use of it to add weight to their religi=ous Cerimonies; it received but few improvements among them. Moral instead of natural Phylosophy seemed to ~~gain the attention~~ have in gaiged the attention of the literati of this Country. In Rome Chemistry first

made

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made its appearance, as a regular science. We are obli-
-ged to the Alchemists for seperating ~~for seperating~~ it
first from natural Philosophy. Many were the disco-
-veries which these men made in their fruitless sear-
-ches after the Philosophers Stone. So great was the ardor
with which they pursued this Visionary Notion, that
Diocletian upon their Art, strictly forbad all chemical
Operations, least his subjects should find out the Art of ma-
-king Gold, & have it in their Power to rebel against him.
This for a while put a stop to all enquiries, & seemed to
bury the Science for some time in oblivion. About the
tenth Century it was again received among many
other usefull sciences in Arabia. — Avicenna, a cele-
-brated Arabian Physician speaks of many Chemical
Operations, & seems to have been well acquainted with se-
-veral Medicines — He wrote besides this very largely
of Alchymy —

From Arabia Chemistry traveled westward into
Europe, & fixed its first seat in Spain. Here many of the
Sciences

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Sciences found a retreat in Spain while every other Part of the World was covered with Ignorance & Barbarism. It may perhaps seem a little surprising (considering the present state of that country) that immediately after that memorable Era, which the invention of printing, together with the Reformation introduced, Spain was distinguished above every other ~~Nation~~ Corner of Europe, in being the Asylum of Phylosophers, & of natural Knowledge. —

From this spot as from a Garden the sciences were transplanted to most Parts of Europe. Chemistry made its next appearance in Germany. This extensive Country abounds more with Mines, than any Country in the World, & hence it became a proper field to cultivate in. Dr. Boerhaave in his elaborate History of Chemistry, gives us a long Catalogue of Authors, who flourished in this Country about the 15 Century. The celebrated Paracelsus from the singularity of his Character is distinguished above them all. Whether we consider this mans great abilities or the Revolutions he brought about in Physic

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Physic, he appears to be one of the most wonderful men that ever lived in any Age or Country. Before this great man made his appearance Galen was the Tyrant of the Schools of Physic. Whatever Opinions differed from those he had established were deemed a Heresy in Physic, & the Spectators of them ranked among the greatest Enemies to mankind. It would take up too much of our time to point out ~~to point out~~ the absurdity of many of his notions, or the Weakness of the Practice in Diseases which were founded upon them. Paracelsus was the first that called his Opinions in Question & disputed his authority in the ~~[illegible]~~ Schools of Physic. He advanced his own doctrine with boldness & Freedom, & notwithstanding their being so unpopular first it was not long before he gained many Proselites. I need not take up your time in repeating the many ~~a~~ Anecdotes which are related of him, They are to be found in every Chemical Book. I am far from agreeing with those Men who pronounce Paracelsus a

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a Madman. Men who think originally & who cannot
conform themselves to the common maxims of conduct
& Opinion which actuate the generality of Mankind
are very apt to Draw upon themselves this Character.
Paracelsus was a man of this kind. (His interprising ~~&~~
spirit, & penetrating Genius led him to doubt of the truth
of every thing which was not demonstrable to his senses)
He rejected all the trifling Hypotheses of the Physici-
ans of his time, & shewed the ~~Fertility~~ inutility of the Endless
~~[illegible]~~ sameness of simple Medicines which were at that time
used in Physic. The conciousness of his own superior
Knowlidge led him to treat all his cotemporary
Physicians with Contempt, which added greatly to
that Resentment against him, which the overthrow
of their Systems of Physic had occasioned. No wonder
then he was obliged to wander from Country to coun-
-try in Quest of a livelyhood, during the Percussion
he underwent, he was no doubt guilty of many
things

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Things which appear to us strange & unaccountable. But we must remember that Opposition as well as Oppression will sometimes make a wise man Mad. I have been the more particular in vindicating that extraordinary mans Character in as much as the treatment he met with has been to often the Lot of those who have devoted the greatest talents & the most time to the service of mankind. It is said that the great Dr. Harvey who immortalized himself by his Discovery of the Circulation of the Blood, drew upon him the envy of his Brethren to such a degree, that he immediately lost all his Business, & was obliged to spend the remaining Part of his Life in obscurity. The great Dr. Sydenham, who is now the Idol of moral Physicians, was the object of general ridicule & Obloquy, among the Practitioners of his own Time. After all this You must not be surprised at ~~[illegible]~~ losing instead of gaining Reputation. Should any of you be

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so successful as to enrich our science with Discoveries or reform our present mode of Practice in the Cure of Diseases. But to Return—

Soon after the Death of Paracelsus Chemistry began to be known & studied in England. Lord Verulam was the first who wrote upon it as a distinct Branch of Natural-knowledge. We are much obliged to this noble Philosopher, for rousing a spirit of free enquiry, not only in his own Country, but all over Europe. To him we are indebted for that admiral Plan of reasoning from facts, which has since been prosecuted with so much success by all the Philosophers who succeeded him.— His Works are deservedly valued as Monuments of the vast extent & force of human Genius. They contain'd some discoveries in Chemistry, but are chiefly valued by the Chemist for the ingenious Methods which he recommends for the Enlargement of his science.

Soon after Lord Verulam, appeared the celebrated

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celebrated Mr. Boyle, who did more Service to Che=
=mistry, than all the authors who ever lived before him.
He was born in affluent Circumstances & was blest
with a most sweet & amiable Temper. He retired early
from public life, & devoted himself entirely to the
Study of Natural Philosophy. He was a person of great
Sagacity & acuteness in minute things. Chemistry was a
favourite Object of his Studies, & as he was possessed with
a large fortune, he was enable to support great numbers
of Operators, who were employed in making Experi=
=ments for him. His writings are published in a plain
easy Stile; He concealed nothing from the Public, except
such things as were entrusted to him as secrets, or
such as he knew would be attended with dangerous con=
=sequences if made public. In somethings he shewed
rather too much credulity, which was owing to his
great Candor in ~~the~~ believing the Reports of Friends,
for as he was ignorant of the Art of Dissembling, he
believed

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believed every one able to be so. He exposed the Philosophy of the Age in which he lived, which consisted too much in idle speculation, & showed ~~too much speculation~~ the world how much Phylosophy & the Arts were connected together. He reasoned entirely from facts & declared in his writings that he learned more from frequenting the shops of Artists, than he did from all the Books, he ever read upon Philosophy in his life. The Works of these two last mentioned great men, spread in a rapid manner thro' all Europe, & created a taste among all nations for Chemical knowledge —

About this time the Royal Society was formed by a number of Gentlemen in London who at first met together in a private manner, & at their own expence & made Chemistry among other sciences, the Object of their Enquiries. Their Example was soon followed by most of the civilised Nations in Europe, who formed themselves into Societies for the advancement of Knowledge.

Ever

Ever since that time Chemistry has been cultivated as a part of natural Knowledge. Many celebrated Chemists have lately appeared in Germany - such as Stahl - Hoffman - Becher - Margraaf & others. Many have appeared in France, who have done much towards ad=vancing the Reputation of our Science. The Cheif of these are Lemery - Geoffroy - Hellot - Le Roy, Buelle & Macquair; each of whom have left behind them, some valuable Tracts upon Chemistry. In England, Chemis=try made but little progress for many Years, which may be owing to the great taste Sr. Isaac Newton left behind him for Mathematical Knowledge, which has for sometime engrossed the attention of the learned men of our Nation. Of late Years indeed Chemistry has been received in Great Briton. & now begins to support that Rank among the Sciences, which its usefulness en=titles it to. Mr. Lewis has spread a taste for it among some people of the first Quality in England.

His

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His Phylosophical Commerce of Arts is one of the most useful Books I know, & shews how much even the most perfect of the Arts may be improved by a Knowledge in Chemistry. Mr. Wolfe an ingenious young Gentleman in the City of London has lately done something considerable in Chemistry. From the great abilities & industry of this young Chemist, something considerable may be expected in the Course of a few years. But among all Chemists who adorn the present Day Dr. Cullen of Edinburg deserves to be mentioned with the most Respect. To a most acute & comprehensive Genius he has added all the Treasures of Ancient & modern Erudition — There is scarcely a Branch of Knowledge in the world which he is not well acquainted with, insomuch that you would think from conversing with him that he had devoted his whole life to that one Study, of which we were speaking — Chemistry was always his favourite ~~study~~ Science. To him we are indebted to the Order & Regularity with which it is studied & taught at present in

most

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most of the British universities. But his Knowledge & discoveries are far from being confined to Chemistry alone. The Theory & Practice of Physic — Materia Medica & even Anatomy itself have all in their turns been improved by his Lectures. In a Word the Assemblage of great abilities & good Qualities which unite in this Great Man, constitute him one of the most finished Characters in the World. Perhaps I may be a little too partial to my much honoured Master. If I am, I am happy in finding all his Pupils chargeable of the same Fault, & I dare say I speak the sentiments of all my Ingenious Colleagues in this College, when I add that should the foundation established for a Medical School ever come to any thing, the Name of Dr. Cullen should be engraved in every Corner stone of it. Nor should we here omit ~~any thing~~ ~~mentioning~~ ~~any thing~~ mentioning the ingenious Dr. Black as professor of Chemistry in the University of Edinburg. He was brought up under Dr. Cullen & has adopted the Plan of his master in teaching Chemistry.

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-mistry. His judicious Paper upon quick lime & fixed Air ~~published~~ published in the second Volume of the literary & physical Essays of Edinburg, will always remain as a monument to his ingenuity & acuteness in investi-gating knowledge. Besides this he has ~~enrich~~ enriched the Science with several other discoveries of which we shall have occasion to speak frequently in the course of our Lectures. This Gentlemen finishes our history of Che-mistry. I have dwelt as little upon it as was possible in order that I might hurry you along to the more use-full as well as to the most entertaining Parts of our Science —

I have taken great care in the preceding as well as present lecture to call Chemistry a science. Most of our late chemical Writers have defined ~~it as an Art~~ Che-mistry to be an Art, ~~& treated it as such because they confined it chiefly to preparations for medicines~~ and

and treated it as such because they confined it en-
=tirely to operations for Medicine chiefly, & the chemical
Arts. Hence we found our common Operators in medicine
distinguished by the name of chemists. Whereas they
deserve that name no more than the Baker, or Brewer,
who likewise put some of the chemical Arts in executi=
=on. You will readily grant there is a great difference
between such persons & the great Mr. Boyle, or the cele=
=brated Mr. Bornecer, who were professed Chemists, &
treated the Science as we propose to do. viz as a branch
of Natural Philosophy. — An Artist is he, who puts in
practice what a man of Judgement finds. Thus for
example Sr. Isaac Newton made great Improvements
in Optics & among other thing formed a plan for ma-
=king a new Telescope, after having tryed many exper-
=iments on different kinds of Metals. In this he ap-
=pears to be only a Philosopher, & he was the Artist, who
by

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by working afterwards in these metals, carried Sr Isaac Newtons Plan into execution. A Physician while he treats his patient secundem Artem, is only an Artist, but when he calls in Theory to his assistance, & reasons upon the Disease of his patient, & the operations of Medicine, ~~he~~ he then becomes a Philosopher. —

Great Care should be taken to distinguish Chemistry from other sciences, & upon this account we cannot be too accurate in admitting a diffenition of it. — Stahl — Homberg & several others define it by telling us that it is the "Art of seperating & compounding metals by means of Fire". This Definition is evidently faulty; for, to say no more of it, Metals are but a small Part of the Objects of Chemistry, & fire is but one of those Instruments, the Chemist employs in resolving metals. —

Dr Boerhaaves Definition of it is as follows. —

" Chemistry is the Art which teaches y manner of per- " forming certain Physical Operations, whereby Bodies

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"cognizable to the senses or capable of being made so, & of
"being contained in Vessels, are so changed by means of pro=
"per Instruments as to produce certain determined ef=
=fects & at the same time discover the Cause thereof for
"the Service of various Arts" —

This Definition is an Error against that max=
=im in Logic, which teaches us that Definitio debet esse
"brevis". Besides this Dr. Boerhaave has mistook the
nature of Chemistry in calling it an Art. He more=
over confined it too much in supposing that those
Bodies, only are to be ranked among the Objects of Che=
=mistry, which are capable of being contained in Vessels.
And at the same time extends too much in saying
that the Physical Operations he talks of will always
lead us us to discover the Causes of certain determined
effects —

Macquair's Definition of it abounds with terms
as difficult to be understood as the meaning of the
Word.

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Word Chemistry itself. In short all who have attemp-
-ted to define chemistry have erred by considering it as
an Art & not as a science, or by comprehending too few
or too many of the Properties of Bodies in their Definiti-
-ons —

Dr. Black after a good deal of Study & reflection upon
this subject has been successfully enough to fix upon
a Definition, which seems to be liable to none of the objects
we have mentioned. It is as follows "Chemistry is the
"Study of the Effects produced by heat & mixture for the im-
provement of our Knowledge in Nature & Arts".
The more we attend to this Definition, the greater rea-
-son we shall have to be pleased with it. Heat & mixture
are two of the most universal agents in Nature. There
is scarce a single Phænominon in Nature or art, but
what depend upon one, or both of these Principles —

Heat is that Grand-principle which enlivens all
Nature. The consideration of the Property of this Ele-
-ment will afford us much pleasure, & Entertainment.
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Let us attend only a few minutes to the different effects Fire produces upon one Class of Bodies, viz Ve-getables, & we shall be able to judge from that how active a principle it is, in all our Operations. By Analogysing Vegetables, some are made to yeild Rosin — others Sugar — some Dyes. of various Colours — & many of them medi-cines — By infusing them in warm water they leave a Virtue behind them, & by boiling them, a medical Mass is collected. A Vapour is produced from them by Distillation, which contains their essential Virtues —

The Ashes of Vegetables (which are obtained by means of Fire) when mixed with Sand & melted together pro-duce Glass, the great usefulness of which, in common Life, as well as in many Arts, you are well acquainted with. The Salt produced from Vegetable Ashes united with Oil forms Soap, which is so very useful in the Arts of Washing, Bleaching & the like. — Thus

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I might go on to illustrate the effects & uses of this Eliment, & show you in general how many different Operations the Metals - Salts & Earths are capable of undergoing by means of heat. —

The Effects of Mixture are no less universal in Chemistry. By means of this assisted heat the Metallurgist learns to flux his metals so as to form them into any shape he pleases. All the different kinds of Paints & Colours, are formed by mixture. —

Petunce & Chaolin, the one a flinty & the other a clay substance, when mixed together form Porcelaine.

Sulphur, Salt-Petre - & Charcoal when mixed together ~~produce~~ in a certain proportion forms Gun Powder.

Copper & Zink, mixed together produce that useful substance called Brass. —

Our Beautiful Varnishes are formed from a Mixture of Resinous substances & Spts of Wine.

Ether is prepaired by mixing Spt. of Wine & certain

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certain Acids together. Neutral Salts are composed of a mixture of Acids & Alkalies. In a word there is scarce a chemical Operation in the World in which mixture is not a very material & necessary Agent. —

Some Object to Chemistry & say that it is not a Science, & does not ~~depend~~ improve our Knowledge in Arts, because many of our Discoveries have been made by Artists who knew nothing of the Principles of Chemistry. Perhaps this may sometimes have been the Case, as men impelled by Interest, & pushed on by a desire of excelling in their respective occupations, have at times fallen ~~into~~ by accident, upon some useful discoveries. But then we are sure at the same time that most of our useful Arts ~~des~~ have been found out & improved by men, who were well acquainted with the principles of Chemistry, & who perhaps were ignorant of the Name only of the Science which unfold these Arts to them —

Before

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Before we proceed to the Division of the Objects of Che-
-mistry, I shall beg leave to lay before you a few gene-
-ral Rules for the Conduct of your studies in the ensuing
Course of Lectures. —

1.st Suffer me to recommend to you in the first place
a spirit of free enquiry. — This will lead you to
make all the knowledge you acquire your own. No-
thing is of more importance to a young Student in
any Branch of Philosophy, than what the Poet calls
"The how consenting Academic Doubt." — Let us not be
imposed upon by the greatness of Names or the Antiqui-
-ties of Authorities, but in every which is of-
-fered to us, let us endeavour to Judge for ourselves —

2.ly Let us be careful in the Choice of Facts. Many
of the Books in Chemistry are wrote by the Alche-
-mists, who abound often in false Facts, as well as false
Theories. Besides this, many Authors have been led into
Mistakes —

Mistakes for want of accuracy in making expe=
=riments — Thus Dr. Arbuthnot for a while fixed the
heat of the human Body at 92.d of Farenheits Ther=
=mometer, but later Experiments have raised it to
98° or 100.° — In the same manner Mr. Geoffroy has
told us that Volatile Alkali has a stronger attraction
to acids than absorbent Earths; whereas the contrary
has been found to be true. Let us farther guard
against such facts as are deduced from Theory. —
Thus Macquiair says, that Salt is a composition of
Earth & Water; but this he does not assert from his own
Experience, but from some preconceived theoritical
Opinion. He afterwards affirms from the same au=
=thority, that metallic substances are formed from Ver=
=trifiable Earths & △, which from Experiments we shall
find to be false —

Microscopical Observations are always in the
same

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same degree distrusted. For Instance Lowenhoecs disco-
-eries concerning the Bl.d have long been received as truths;
he affirms the red particles are of a Globular figure, &
consists of six lesser Globules. whereas, Dr. Senac affirms
that they are lenticular. Dr. Haller that they are sphe-
-rical, & neither of them observe any thing that looks like
the Conformation, which Lewenhoec speaks off. Mr. Hew-
-son an ingenious Anatomist in London, has lately showed
that each of these Authors are mistaken, & that the red
particles of the Blood, are of a flat somewhat resem-
-bling the form of an English shilling —

All Facts which are said to be universal are
to be suspected. General Principles are certainly very
necessary, but at the same time very difficult to be
established, & should always be received with diffidence.
Thus effervescent mixtures have all been supposed
to produce heat. but we know that some of them
produce

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produce Cold.—

Again authors are sometimes mistaken in assign-
:ing ~~one~~ one cause for an Effect, which several causes conspi-
:red to produce. Thus it has been asserted that the freezing
of Water is owing to Cold. But water in its fluid state
contains a great Quantity of Air, & it must be deprived
of this Air before freezing can take Place.—

We find considerable inconvenience also from not
knowing the particular circumstances of Facts.—

Thus for example, we are told that Brass is a mix:
:ture of Copper & Zinc, yet we find no authors ~~that~~ who
tell us any thing about the Phenomina, which accom:
pany the Union of these two metallic substances together.
whether an Effervescence succeeds the mixture,—whe-
:ther heat or cold is produced—whether there is any sepe-
:ration of Parts—whether the specific Gravity is les:
-sened or encreased—whether there is any alteration in the

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the appearance of their texture, & lastly whether any Change takes place in the fusibility of either. From all these examples we conclude, that there are but few Facts, which are sufficiently pursued, or ascertained, for the purposes of Philosophy or medicine —

The Plan I propose to follow in the following Lectures, Gentlemen, is as follows I shall

1st treat pretty largely of the general effects of heat —

2d I shall speak of the general effects of mixture. —

3dly I shall describe the Vessels & Instruments made use of in performing the Operations of Chemistry —

This comprehends what we shall call the first part of our Course — The second Part will contain the Objects of Chemistry, which we shall divide

1st Into Salts —

2d — Earths —

3d — Inflammable substances —

4th — Metals —

5th — Waters —

6th — Animal & Vegetable substances. In

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In treating of each of these Classes of Bodies, I shall
1.st treat of the Effects of heat. –
2.ly of the effects of Mixture upon them. –
Under these two heads we shall be able to include all their chemical Properties. – After this I shall conclude with a ~~very~~ short account of their natural history. – I know it is very common in the Introduction to Courses of Chemistry, to take up a lecture or two in defining & explaining the Terms of Art, as they are called. I shall for your sakes differ from this Custom, & instead of loading your memories with definitions which at first setting out, I shall always defer explaining the meaning of a Term, till we have occasion to apply it immediately or to illustrate it by an example –

It is a common Question in the Introduction to a Course of Lectures, for Young-Gentlemen to enquire what

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what Books they should read upon the several Bran=
=ches of Medicine they are studying — I must ac=
=knowledge that I am at a loss to know what Books
on Chemistry to recommend to you. — Dr. Boerhaave's
Chemical Works are chiefly valuable for the accounts
they contain of the Operations of Chemistry — but these
are often tedious, pompous & sometimes Faulty.
Mr. Boyle's Works may be consulted with advantage.
His natural History of Cold — his chemical History of
the Blood — of the Air — of precious stones are well
worth your reading. Besides these he has here &
there many valuable facts interspersed thro' his works.
~~Macquiers~~ Macquairs Elements of Chemistry is
a Book which should be in all your hands. It is the
most perfect of any thing that has ever yet been pub=
=lished on the subject. He is however very faulty in
point of System, & I am sorry to add, I shall often have
occasion

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occasion, to mention for the sake of pointing out his Defects — To such of you Gentlemen as are acquainted with the French Language, I would recommend the Dictionarie de Chemie wrote by the same author. together with the ingenious Mr. Margraafs facts on Chemistry, which were originally published in the memoirs of the Academy of Sciences at Paris, & are now collected into two neat Volumns — The trans-sactions of the Royal Society of London contain many valuable papers upon chemical Subject. I would recommend them to such of you, Gentlemen as can get access to them & have leisure to look thro' them. —

This finishes our Introduction to our course In our next Lecture Gentlemen we shall begin to speak of the Effects of Heat. —

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Lecture 3d —

The Effects of Heat — —

Gentlemen;

Before we proceed to say any thing concerning the effects of heat, I must premise that I do not propose to account for the Cause of it. — Lord Bacon has taken a great deal of pains to ~~ac-count~~ prove that it depends upon Motion. This he infers from the heat which is produced by the Friction — Percussion — & Collision of Bodies, each of which set their particles in motion by a kind of Force. If we admit this Theory the cause of heat is explained at once, but plausable as it appears to be it will not account for the Effects of heat, for daily experience convinces us that heat is by no means proportioned to motion. —

Others have told us in a few words that "heat

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"Heat is a tremor or Vibration of an elastic Fluid, which pervades all Bodies". This Fluid is called by Sr. Isaac Newton, by the name of Æther, from which he explains all the Phænomena of Electricity - Magnetism & even Gravitation. - There are some things which make this Theory probable & others again which refute it. None who have attempted to explain the cause of heat, have met with better success in their Conjectures than those we have mentioned

By heat I understand the Power which is capable of exciting Expansion - Fluidity - Vapour & Ignition in Bodies. We shall treat of each of the Effects of heat seperately, but previous to this it may not be amiss to treat of those general Laws, which we obtain with Regard to the communication of Heat. - &

1st. The communication of Heat is common to all

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all Bodies. They each of them receive & impart it to one another, & this communication of it continues till all surrounding Bodies have acquired the same degree of heat or till the heat is brought to what is called an Equilibrium –

This shows that the expansive power of heat ~~which~~ is always endeavouring to recede from its centre.

The action of the Sun is the most general source of heat, from whence supplies are derived to replenish that, which is constantly flying off. Heat every where exerts an Expulsive or expansive Power – without showing any Tendency to be attracted by particular bodies, it appears that it is common to all of them, but particular to none. The Difference in the Degrees of Heat in different Bodies is owing according to the Opinions of some to the Difference of Vibration excited in such Bodies. –

2ly The Communication of heat between two Bodies requires some time, & different times are required for different Bodies.

3ly The Bulk of the Body & the Quantity & Quality of the matter being given the heat lost or received will be proportionable to the surface. Hence it follows that the Figure of Bodies has considerable weight in determining the communication of heat thro' them, the larger their surfaces are the Quicker they are affected by heat & Cold. A Cube of a small surface grows hot much sooner than a Cube of a larger surface, tho' its form & density are exactly the same, because the surface of the small Body is greater in proportion to the Quantity of matter it contains, than the surface of the larger one, in the same manner a piece of gold Leaf

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Leaf extended so as to weigh exactly as much as a gold Sphere or Cube will grow hot & Cold by much the quickest. A given Quantity of matter will communicate or receive more heat in the form of a Cube than it would do in the form of a Sphere. —

4ly The Figure, Quantity & Quality of Bodies being given, the heat lost or received will be somewhat proportioned to their Bulks. —

If we suppose an Iron Ball to consist of a Number of connective Layers, heat communicated to it will pass slower & slower from one Layer to another towards the Centre. — Whereas in returning from the Centre again to the Circumference of the Ball, its Motion will be performed in a less time as it passes from the lesser to the greater Layer, which surrounds it.

5ly Heat passes out of any Body in the greatest proportion

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Proportion, at the Part, where the layers are fewest. –

6^{ly} Heat passes from one Body to another in propor=
=tion to their contiguity, or close & extensive communica:
:tion of Parts. Spherical Bodies donot communicate
heat, when they touch, near so fast, as Bodies of a cubi:
:cal form, because they touch only in one Point whereas
the extent is greater in the Cubes. –

7^{ly} The surfaces & Bulks of Bodies being given, they
loose or receive heat, in proportion to the particular
Quality of matter.

8^{ly} With Regard to the communication of heat, is,
that it always has a tendency upwards, this may
be demonstrated by holding our hand over a red hot
Peice of Iron, when taken from the Fire. In a clear
Sunshiny-Day it may be seen ascending in irre=
=gular Fumes. This does not obtain in Vacuo, for
their

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their heat is distributed in an equable manner, as we may perceive by throwing red hot Iron into an exhausted Receiver, after the small remains of air within it have been confined, becomes as hot as the other Part of it. Ice & cold Bodies ~~below~~ have a contrary effect to heat, & tend to make the Bodies below them colder — Heat applied to the Bottoms of Fluids, heat them much quicker than when applied to their surface, it rarefies all Fluids, & thereby disposes them to ascend, it is distributed more equably — Water has been employed by Chemists to heat bodies equally, & obtained the Name Balneum Mariae or Maris. It can be heated to 212° in Farenheits Thermometer — Lewis substituted mercury because it will receive more heat & make a more powerful solvent on Bodies.

There

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There are Conductors & Non-conductors of heat as well as of Electricity — it may be even made a Query whether Air or Water grows hot or cold soonest. It is probable that water receives heat most readily, because heated Bodies grow cold sooner ~~than~~ in water than in Air. All fluids or metals are quick conductors of heat, as well as Electricity. Wood conducts heat slowly, hence appears the use of wooden handles to Instruments, applyed to the Fire. If there is any absolute Non-conductors of Heat it is air, for it is somewhat doubtful whether heat is conveyed thro' the Air, otherwise by the means of heterogeneous particles diffused thro' ~~the air~~ it —

We have another Analogy between heat in wool This substance does not convey electric matter, & conveys heat & cold very slowly — hence its great use in Cloathing. The Nations of cold Countries employ Furs

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Furs, Feathers &c. Ice we find is kept from mel:ting during the heat of Summer by being wrapped up in hay— Straw — Wool & the like — for the heat passes every where slowly thro' these Substances & are generally surroundedg by some one of these Bodies, hence the Reason why snow renders the Soil fruitful; it preserves Vegetables from frost by its being a soft spongy Body. The codler the Climate the more snow. Nature seems to have been as provident of the Earth, as of the Animals of cold Countries, furnishing the one with Furs & the other with downy Blankets of Snow, this Communica:tion of Heat does not extend to Fluids — —

Water collected in large Quantities preserves nearly the same Temperature in very great changes of Air. The further we are from the sea, the colder because the wind in passing over an extensive

tract

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tracts of Land, does not rob the Earth of any of its heat whereas in passing over the sea, they are considera=bly warmed by the heat. England which lies between 50° & 60° North Latitude is not so cold as in this ~~Climate~~ Pro=vince, this is owing partly to its being surrounded on all sides with Water. We find the Air in Valies always warm, the Tops of high mountains always cold in summer, even in the hotest Latitudes — The hail which falls on high mountains, is a proof of the extreme colds prevailing in the upper Regions of the Air. —

— Air rarefyed always extends upwards; Why does it not ascend & warm the Air above it? To explain this we must remember that heat de=pends upon the sun. The Sun we know produces no heat upon transparent Bodies, but only upon

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upon opake Bodies; & the more opake the Body the greater the heat produced. The Rays of the Sun warm only the Surface of the Earth & the ~~Sun~~ Air receives its heat entirely from the Earth; this is the Reason why the Air nearest the Earth is always warmest. Some Circulation is no doubt produced in the Air which is warmed by the Earth, but being compressed by the Air above that it cannot ascend to a great height; This compression makes the Air nearer the Earth very dense insomuch that when it is most rarified it is always denser than the highest atmosphere. Other causes no doubt concur to constitute diversity of Climates. The difference in Climates depend upon the following Causes. —

1st The Suns greater ~~Distance~~ or lesser Perpendicularity to a place. —

2d On the contiguity of Lakes or Water, which send

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send forth heat in winter, to warm the Earth, & prove the cause of Breezes & Vapors, which produce Coldness in Summer. Hence Islands are cooler in Summer & warmer in Winter than continents

3^{dly} The Difference of Climates depend on ~~particu~~ ~~lar winds~~ the Quality of the soil on which the Beams of the Sun fall, where it is stony or rocky the Air will be much warmer than where it is sandy, this you understand by recollecting the 7th law of ~~that~~ the communication of heat we mentioned.

4^{ly} Climates are varied by the Contiguity of mountains, which screen a place from cold winds in Winter, & cool the Air in Summer, by means of Snow which covers them.

5^{ly} The Diversity of Climates depend on particular Winds blowing from different Quarters of the Globe

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Globe —
6^ly^ Upon the presence of Clouds which obstruct the suns Rays —
7^ly^ & lastly. Climates are much varied by the situation & state of Culture. — In Italy Storms of hail & snow were common some hundred years ago. — The Tyber has not been froze over for many years past. From this fact we may venture to foretell that this Country will undergo the same change future Ages will hardly beleive that a public road was kept open for several Weeks together upon the Ice on the River Delaware between this city & our neighbouring Province. &c —

Having now finished our account of the general Laws of ~~matter~~ the communication of heat, we shall next proceed to treat in the manner proposed of the Effects of heat, I intend to treat it

as

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it as a simple Quality of Matter, & confine its Effects to simple Bodies only such as Metals — Earths — Waters & the like. Animal & Vegetable substances are composed of different Particles, & may be decomposed by heat; upon this account they do not come properly under our notice while we are treating of the general Effects of heat. — Heat we said before always produces one of these four effects on Bodies. —

1st Expansion —
2d Fluidity —
3d Vapour &
4th Ignition —

We shall first speak of

Expansion —

all the Bodies we are acquainted with in nature are capable of being expanded by means of heat. We

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We have but one exception to this general Rule which we shall mention hereafter — Two or three examples will illustrate this Fact. All matters may be comprehended under one of the three following Forms. —

1st Solids

2d Inelastic, incompressable fluids.

3dly. Elastic compressible Fluids. —

We shall illustrate each of these by a single experiment.

1st If we take an Iron Cylander, & heat it red hot we shall find it cannot be introduced into a hole it filled before.

2dly If we pour a little Spt: Vin: in a little Tube, marked with a peice of paper & dip it into warm water we shall find the Spt Vini will rise — then plunge the Glass into cold Water & the

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▽ will return to its former state — to illustrate the 3^{d} Division of matter, we shall take a Bladder, half filled with Air & hold it near the Fire. The warmth of the Fire will expand the Air gradually & uniformly, after a while the Bladder ~~bag~~ will become fully distended from the Expansion or Elasticity the air receives from the heat. Expansion or Contraction are always the Consequences of heat & cold. Different Bodies are acted upon differently by heat. Some expand more some less. We observe these things but we cannot account for them. In general we find the densest Bodies expand least, but this is not always the Case, for some metals expand more by heat than Glass, therefore we must have recourse to the Experiments alone. —

One of the French Accademicians has publish=ed an accurate table of the different degrees of ex=pansibility

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-pansibility in Bodies made my means of an Instrument called a Pyrometer.—

These Experiments may be usefull to Artists in making nice Machines, where any of the metals are concerned, in as much as cold & heat act in so surprising & so uniform a manner upon them. Some of them have availed themselves of this discovery, & hence we find in making large Tubs for brewing the smiths always heat their hoops red hot before they nail them to the Tub, for no mechanical Force whatever would be great enough to make them set firm to the Tub, unless they were first heated & then suffered to contract around the Tub by means of the cold.— The same practice is likewise followed in making those kind ~~Germany~~ of millstones which are called French Burrs. A Number of small stones are united together by means of Plaister of Paris, & afterwards surrounded with Iron Hoops red hot which after they contract give the greatest degree of Compactness & firmness to ye Stones, & thus render ym ye most harder & durable materials for the purposes of dividing the Grain. Lect: 4th

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The only Body in Nature which resists the contractile Power of Cold, ~~&~~ thus proves an Exception to the general Rule we have laid down is water. This fluid is encreased instead of being deminished in its Bulk when it is converted into Ice. In order to be assured of the Truth of this Fact Mr. Boyle put some water into an Iron Tube which was 3 Inches in Diameter. Upon this tube he placed a weight of ℔70, & afterwards exposed it to an intense Cold. The water was no sooner frozen than the Tube was so enlarged that the weight placed above it was raised in a very sensible manner. Mr. Hagem an Eminent Phylosopher of the last Century bursted a cannon in trying this experiment. But nothing affords a more striking Instance of the Expansive Force of Ice than the Florentine Experiment. A Number of Gentlemen having procured a small hollow ~~tube~~ brass Globe about an Inch in Diameter filled it with water & put it into a mixture of Snow & Salt in Order to freeze. After Standing for sometime in this mixture without discovering any Marks of freezing they took it out & paired away some of the Brass, from the Globe & then put

into

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into the freezing mixture upon which it bursted with a great Explosion. <u>Mushenbrock</u> even puts the resistance overcome here to be equal to 27,000,700 weight & some odd Pounds, & supposes further that the Bulk of the Water becomes $\frac{1}{10}$ part greater by being froze — These Phenomina will explain to us the Reason why <u>frost & gentle Rains</u> contribute so much to the fertility of the Earth — For the water being first Insinuated into the ground, is there converted into frost, which by expanding, causes it to Crumble into pieces; & ~~after that~~ it becomes afterwards more easily penetrated by the Roots of Plants, as well as by the external Air, the last of which contributes not a little towards promoting the growth of Vegetables. — We may learn likewise from what has been said why Pavements become so loose after a sudden Thaw, & why Houses moulder away gradually especially after a long & cold winter. The Reason why Conduit Pipes, which are so much used in most parts of the World for supplying large Cities with Water) I say the Reason why these are sometimes bursted in extreme cold Weather is now no longer a mystery to us. It is owing to their running too near the surface of the Earth, by which means the

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cold has Accefs to them so as freeze the water, they contain, the Consequence of which (as we have already said) must be the Breaking or Distruction of every thing which resist it —

— Phylosophers have puzzled themselves much to explain the Cause of this expanding quality in Ice. — Homberg thinks it is owing to the Air which the water Contains, which he says may be seen in an expanded state in every Lump of Ice. In answer to this I would ~~venture~~ observe in the first Place that it is the Uniform effect of Cold to condence or to deminish the bulk, & not to expand, or encrease the Bulk, or space of a given quantity of Air. — But 2^dly^ M^r^ Meran & M^r^ Mushenbruck have proved that it cannot be owing to the Cause, assigned by Homberg, for having deprived a Quantity of Water of its Air, & afterwards exposed it to the Cold, they found that it still expanded upon being frozen, & likewise that it still retained the appearance of Air Bubbles distributed thro' it. But 3^dly^ D^r^ Hales has placed the matter out of Dispute, for having put a piece of Ice under Water he peirced Holes into several of the Bubbles, & found that the Air did not rush out with any force, which it certainly

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certainly should have done, had it been in that strong expansive state which Homburg supposes.

Instead of this Theory of Homburg's, Mr. Mairan has proposed an opinion of his own to account for the swelling of Water when it is converted into Ice. He supposes that it it is owing to a strong Tendency which the Water has to place itself in Ranks so as to cut each other at angles of 60°.— That this is really the Case, he endeavours to prove 1st from the appearance of Ice which is seldom smooth, but generally rough & irregular; & 2dly From its resemblance to Particles of Snow, which are formed from Water frozen in the Air. These Particles of Snow have a Radiated, star-like appearance, & always cut one another at Angles of 60°. I am well assured that there are some Chemists of considerable note, who tell us that this Figure ~~meaning~~ of the snow is owing to its containing ~~place~~ a saline Matter mixed with it. But Mr. Margraaf of Berlin has proved, that this Opinion is entirely without Foundation, & that snow instead of containing any quantity of Salt in it, is the purest & most homogeneous Fluid in Nature. This Figure therefore of the Particles of Snow

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Snow affords a strong Presumption in Favour of the Cause assigned by Mr. Meram concerning the expan=
=sion of Water when converted into Ice. —

— We said a little while ago that Water was the only body in Nature, which resisted the contractile Power of Cold. But Mr. Reamur (of the French Academy) has en=
deavoured to find ~~the~~ out another Exception to this gener=
ral Rule. He tells us that there are several metals, & in particular that Iron expands considerably on becoming Solid. This has been frequently observed by those ~~Chemists~~ who work in Iron, & has been attributed to a cavity in the Metal, which we are now ~~[illegible]~~ sure is not the Case, as we find it pretty uniformaly in other Metals, as well ~~[illegible]~~ as in Iron. In order to account for this we must remem=
=ber that several of the ~~[illegible]~~ Metals are very brittle & Crumbly, & that their Constituent Particles only touch at Angles, & do not unite intimately, ~~[illegible]~~ & hence we find Cast Iron is never so compact as wrought Iron. —

— I go on to consider another Property of Heat under our 1.st Head, & (i.e.) that it expands inelastic mat=
=ter such as Waters & the like; with a force that is almost irresistable

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irresistable. We want no other Proof of this obser-
vation than the well known Florentine Experiment
in which an attempt was made to compress water in
Gold. This Expt. By the by was supposed to prove that
Water was incompressible, because it transuded thro' ye
Pores of the Gold. But an ingenious gentleman (whose
Name I do not recollect) has demonstrantted in the
Philosophical Transactions for the Year 1762, that this
Opinion is altogether void of Foundation — for having put
a quantity of Water into a Glass tube with a bulbous end
to it somewhat resembling a Thermometer, He took of from
it the pressure of the air by means of an Air pump, This
is a Circumstance but little attended to in making Exper-
iments of this kind, for the Height of ~~this kind, for the~~
this Fluid being (as we observed in our last Lecture) near
50 Miles cannot fail of pressing with great force upon
all bodies. As soon as he took of the Pressure of the Air
from the Water he found that it arose sensibly in the
Glass, which proves that water in its Natural State is
always more or less compressed by the surrounding or im-
pending Air. But

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But to return. — It is somewhat surprising that Bodies which have been increased by heat, or diminish=ed by cold, suffer no alteration in their weight. Mr Boyle & Dr Boerhaave have ascertained this fact by a great Number of Experiments. Mr Muschenbruck, indeed has since contradicted it, & tells us that upon melting ℔j of Lead & ℔j of Tin, they each of them lost several grains of their weight, which they recovered again when they grew Cold, but he forgot that this small Deminution of their ~~are~~ Weight in their state of fusion, was occasioned by the surroun:=ding Air, being rarefied, & therefore much of its Pressure ta=ken off from the Metals. Fluids likewise, such as water & the spirit of Wine, are no ways affected by heat & Cold as to their weight. — Mr Muschenbruck has added another Remark upon this subject, & that is, that Metals when reduced to a powder ~~by~~ or calcined, are much heavier, than when in a solid form. Thus for Example ℔100 of Lead upon being reduced to a Powder, weighs ℔110. This has been supposed to be occasioned by the Metals receiving & fixing a quantity of heat, but we shall show hereafter when we come to treat of the Metals, that it is owing to their

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their having something abstracted from them. — —

— I shall conclude this account of Expansion with one observation, (i.e.) that no body in Nature contains a definitive, or certain Quantity of Heat in it, nor can we ascertain how far Bodies may be expanded, or compressed by means of heat or Cold. Some have gone so far as to say that the Air around us might ~~be~~ so compressed (could we abstract all its heat from it) so as to become as hard & solid & Gold. — — — — — —

— We are naturally led Gentlemen, from what we have said of Expansion, to say a few ~~things~~ Words upon Thermometers. — The usefulness of Which in ascertaining the degrees of heat & Cold, & thereby enlarging our Knowledge of Climates & Diseases is well known to you all. — As the proper application of these Instruments, is often extremely usefull in Medicine, as well as in all the Branches of Experimental Philosophy. — I think it will not be improper to enter into a full Discussion of them in this Place. We shall endeavour chiefly to point out the Fallacies or Inacuracy that may occur in their Structure or use. — — — — — — —

— For the Purposes of making Termometers, we ~~shall~~ generally ~~—~~ choose Bodies which are most sensible of Heat

Heat. Such Bodies as we said before in our last lect= are Fluids. There is one Disadvantage attending the Use of all Fluids & that is that they will only measure Heat to a certain Degree before they are converted into Vapour. This Difficulty however is pretty well obvia= ted by a Calculation which Sir Isaac Newton has proposed, of which we shall speak more fully when we come to treat of the use of Termometers. — — —

— The Fluids generally employed in making Ther= =mometers are. 1st Air. 2d Alcohol or Spt. of Wine 3d Oil & 4th Mercury. — Air was the first Fluid that ever was made use off for that purpose of measuring heat. Its great sensibility to heat & cold, & its application to this Important Discovery were first taken Notice off by Sanc torius. The Thermometer he invented was rude in its Form compared with those, which are at present in use amongst us, but still he is entitled to the greatest hon= =nour, since all the Improvements which have been since made upon this Instrument, were first suggested by his aukward attempt to make one. It consisted of a Tube with a Ball on one end & a hole in the other.

The

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The opened End of the Tube he put into a Vial filled with a coloured liquor down to the bottom. Upon applying heat to the Ball, the air within becames ~~a~~ rarefied & the Liquor in the Vial sends forth Bubbles. when any thing cold is applied to this Bulbous head, the Air is again condensed, & by these means the coloured Liquor rises in the Tube. — — — — — — — —

— Mr. Boyle has made some Improvements in this Thermometer – He took an open Tube, & immersed one end of it into a Vial which was filled with a coloured Liquor. – He then sealed the Vial Hermetically & blew Air into it with some force, which by its Pressure, raised the Liquor in the Tube, which liquor rose & fell in proportion to the Density or Rarefaction of the Air. This is doubtless a much better Thermometer than Sanctorius's, when we would observe small Variations in Heat & Cold. — — — — — — —

— By sealing any thing Hermetically I mean closing it up in such a manner that no Air or Water can pass thro' it. The Word is derived from Hermes an Egyptian who was supposed to be acquainted with many Operations in Chemistry. — — — — — — — — — — —

— Altho' Air possesses the greatest Advantages of being so very sensible ~~of~~ to Heat & Cold, yet its Expansibility is

so

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so very great that it is almost impossible with any Convenience, to have a scale long enough, to measure the Changes which occur in the Atmosphere. Besides this, Thermometers made with Air are liable to be affected by the Density, as also by the different state of Moisture & Dryness, in the atmosphere, independent of its heat & Cold, so that they are only fit for transitory Experiments & for such they are perhaps better adapted than any Therm^r. yet invented. — — — — — — — — — — — —

— Alcohol or Spirits of Wine has sometimes been used for Thermometers. The Spirit in these Cases is always tinged with Cochineal, that its motion in the Tube may be rendered more observable. It is very sensible of heat & expands very readily, nor will it freeze except in great Degrees of Cold. It will not however show great degrees of Heat upon the account of its boiling Points being considerably less than that of water. It may notwithstanding be employed in many Experiments. It possesses this great Advantage of not changing for a great number of Years.

— 3^dly Oil. has been used sometimes with tollerable success for shewing the Changes of the Temperature of the Air. For this purpose the expressed

~~expand~~

List 4th

expressed Oils of Vegetables are most suitable. It is capable ~~the~~ of enduring an intense heat before it boils, nor will it freeze except in a great Degree of Cold. But a moderate degree of Cold gives it such a Viscidity as renders it entirely useless. — — — — — — — — — — — — — — — —

— 4th Mercury has more Advantages to recommend it than ~~either~~ any of the fluids we have been speaking off. It is next to Air in its sensibility to Heat. It resists freezing more than any other fluid, nor does it boil except in very considerable degrees of Heat. Besides this is not liable to expand too much, so that it does not require a very long scale, & consequently will always shew the smallest changes in the Temperature of the Air. Upon the whole Mercurial Thermometers are the best Instruments, that can be contrived for distinguishing accurately the Changes in the Temperature of the Atmosphere. We shall now add a word or two concerning the Construction of these ~~[illegible]~~ Thermometers. —

1st The longer the tube of a thermometer be in proportion to its stem, the greater will the scale be & the expansion of the ☿ more evident, but then as the Bulb becomes larger its sensibility becomes less. You will understand the ~~Reason~~

Reason

Reason of this from recollecting the third Law we mentioned concerning the Communication of heat which was the Bulk of a body & the Quantity & Quality of ~~the~~ matter being giving, the heat lost or received, is pro=portioned to its surface. — The Glass of which the bulb is composed should be as thin as possible, it would be better to make it in the form of an oblong or Oblate spheroid than in the shape of a perfect Globe. Since by Hemispheres more of the surface of the contained fluid will be exposed to the action of heat & Cold. This likewise depends upon the 3d Law of the Communication of Heat. —

2dly The Perfection & accuracy of a Thermometer depend in a great Measure upon the Uniformity of the Cylin=drical Tube. In order to know when this is the Case put two Inches of Mercury into a tube, & lay it on a table & see whether it measures exactly 2 Inches all the way thro' — If it does you may depend upon it the Tube is an exact Cylinder. You may use a piece of Card or Paper 2 inches in length as a standard for this measure. —

3dly A Direction commonly given for making Thermo-meters to exhaust the tube as much as possible of all its

air

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Air it contains, least any of it should by any means sepe=rate & divide the Mercury in the scale. But in contradic=tion to this Mr. Wilson an Ingenious Type Founder in Glasgow, who makes the most perfect & Thermometers, of any man in Europe, tells us that the air, tho' left in the tube, does not sensibly counteract the expansion of the contained Fluid, & that the weight of the Air does not affect the mo=tion in the Tube

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Let us next speak of the Graduation of Thermometers. A scale divided into any number of equal Parts, may be applied to the tube, after it is filled with Mercury. But, unless some general Rule is established, & followed where we shall begin, & where we shall end, our Points of Gra=duation, we can never compare our observations with those of others. Two standard Points have therefore been fixed upon for this purpose viz. the heat of boiling & the Cold of freezing water. We are much obliged to Dr. Martin for his accurate experiments on this subject. He tells us that he put a Tube with Mercury in it, into snow & found upon repeating this over & over near an 100 times, that it always reduced the Mercury to one ~~freezing~~ certain Point. after

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After this he varied the Experiment, & dipped it into boi=
=ling water, & found ~~that~~ upon repeating this Experiment
as often as the former that the Mercury always rose to
one certain point likewise. When he took a smaller tube
he found the snow & boiling water produced the same ef-
fects upon the Mercury only with a proportionably smal-
=ler distance between the freezing & boiling Points, having
thus far succeeded, he marked the middle points of the
Distance, between heat & Cold, & afterwards marked the in=
=termediate degrees of heat. — This Thermometer from some
Improvements it received from Farenheit has always
gone by his name. The boiling point in this Case is
marked at 212° & the freezing at 32°. —

In graduating Thermometers we should always en=
=deavour to determine the boiling point of water at a middle
state of the Atmosphere, (i.e.) when the Mercury stands
at 29 Inches in the Barometer, for when the weight of y^e
Atmosphere is less, there is less pressure on the boiling water
& the Liquor of the Tube will not rise to 212° which is the
Boiling Point in Farenheits ~~Thermometer~~ Scale.
The Reverse of this Proposition likewise takes place.

I intended to have illustrated what has been said upon this subject, by making a Thermometer in your presence, but as we are not so fortunate just now, as to be able to procure any snow, I ~~that~~ cannot accomplish it. I flatter myself however from the account we have given of them that there are few Gentlemen here but what could make one for themselves. —

§ A 4th Circumstance to be attended to in the structure of Thermometers is not to suffer the Bulb of it to bee too bright. All lucid Bodies have a property in them not only of reflecting the Rays of Light but of heat likewise.

Of this we have daily examples in our kitchens. If a bright pewter Dish is put behind a piece of meat, while it is roasting before ye fire, it will not acquire any heat, altho' it stands there for ~~many~~ several hours, while at the sametime it reflects so much of it, ~~as~~ as to warm the hand considerably when put before it. This Caution with regard to the Brightness of the Bulb of the Thermometer, was first communicated to me by Mr Patrick Wilson, Son of the before mentioned Type Founder, at the College in Glasgow, who was led to make this remark by observing a Thermometer ~~that~~ which stood in his Room, to stand several Degrees

below

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below the Heat to which all the Thermometers in the College at that time pointed. Upon daubing the Bulb of it with a little Ink he found that the Mercury soon rose so as to stand ~~on an equality~~ exactly on an Equality with the other Thermometers. (return to 86)

This finishes all we had to say in regard to the structure of Thermometers. I thought it necessary to dwell a little upon them for by this means our Ideas of heat are greatly enlarged. We are from hence taught that nobody is so cold as not to afford some heat, nor is there any body in Nature so cold, but what it may be rendered more so. As for Instance snow itself may be ~~added~~ made much colder by adding Salt to it, which is a sufficient proof of the coldest bodys ~~bea~~ containing some heat. Here take Notice I speak of heat in a positive & of Cold in a negative sense, which I take to be the best way of speaking of them as we are Ignorant of the degrees of in which they terminate. We are very apt to think Fluidity the Natural state of water, & that Ice is ocasioned by a certain active principle called Cold, which condenses the water & hence we conclude that all bodies above Ice are warm & all bodies below it ~~warm~~ cold. But this is a Vulgar & most absurd ~~Idea~~ error. There are many Bodies

Besides &c. see ~~87~~

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There are many Bodies besides Water, which are fluid when they are hot, & become Solid again ~~when~~ as soon as they are ~~cold~~ deprived of their heat. It is not improbable that Lead & Tin would always be in a fluid state if they were lodged in the Planet Mercury. Our Sensations of heat, & cold, have biass to make use of a Language, which tends to keep up the Vulgar opinion of Cold & heat being both positive Causes.– Whereas we mean no more by that Language than heat & Cold tend to excite positive Ideas in our minds of their respec=tive Qualities. Nothing can be more precarious than to form our opinions of Heat or cold of bodies by our sensations of them since the same Water will feel hot or cold at different times according to the different Degrees of heat in our Bodies at the time we try the Experiment.

Heat then I look upon to be a positive Cause, & suppose that it is derived from the Sun. Cold I look upon to be a negative Quality (if I may be allowed the Expression) & occa=sioned entirely by the Absence of the Sun.–

I shall take no notice here of the common opinion which Vanswieton & others have adopted of cold being produ-

ced by

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by sharp saline Particles in the Air, but I shall hereafter consider ~~the~~ it as owing to nothing else ~~but~~ than a mere absence or Diminution of Heat.

Let us now attend a little to the History of Cold. Dr. Boerhaave speaks with surprising of a Degree of cold 32° below 0. In Farenheits Thermomr. But Farenheit produced a more intense Cold than this by mixing Snow & aqua fortis together. The Mercury when placed in this fell 72° below the freezing Point or 40°. below the Scale. In the Memoirs of the Royal Academy of Sciences, we have an account, which far exceeds that mentioned by Dr. Boerhaave. Several of the Academicians were sent by the King of France, to the polar Circle in order to determine the exact Figure of the Earth. There they had no Sun for sometime, & were obliged to keep themselves closely confined in a warm Room with a large fire constantly burning in it. They tell us that the Timbers, of which their houses was built, would often crack in a most terrible manner. This was occasioned no doubt by the water, which had insinuated itself into the Timbers, ~~&~~ becoming Ice, & so producing the expansion we before spoke. They relate further that when they opened y Door

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Door of this Room & breathed in the open air, their breath froze into Snow & that the Air when inspired produced a most Violent Pain in their Lungs. In this cold Region they tell us that Spt. of Wine froze & that Mercury fell 33° below the lowest point in Farenheit Thermometer which is 65°. below Frost, & is as much colder than Frost as hu=man Blood is warmer. We cannot help admiring the resolution of these illustrious Philosophers, who under:went hardships in quest of a Piece of Knowledge, which many would shrink from in Pursuit of the most im=portant & interesting Objects in the World. —

But there are some late Experiments which teach us that some Parts of Siberia are much colder than the Climates of the Polar Circle, where the aforesaid Ob=servations were made. — The Reason of this may be owing to Siberias being at such a distance from the Sea, which we know know contributes much to lessen the Natural Coldness of Climates. We are assured by Professor Ammon in a Letter which he sent to Sr. Hans Sloan that the Mercury in that Country fell 155°. below the the lowest Point in the Scale of Farenheits Ther=mometer, & yet the same Gentleman observes in the same Letter

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Letter that the finest & rarest Plants in the World, are found in that Part of Siberia, where this intense Cold prevailed. This Fact altho' foreign to our ~~pre~~-~~sent~~ present Subject tends greatly to enlarge our Ideas of Vegetation, & may be useful to us when we come to deliver the Chemical History of Vegetables.

In the Phylosophical Transactions of Petersburg we have an account of an Artificial Cold far more intense than the last we have mentioned, produced by Mr. Braun by mixing snow & aqua fortis together. The Natural Cold of the Air of Petersburg was 40° below ~~the~~ 0 in Farenheits Thermometer, when he put the Thermometer into the mixture of snow & aqua fortis, the Mercury fell 352° below ~~the~~ 0 in Farenheits Scale. Upon breaking the Tube he found the Mercury was converted into a solid form. He observed that the Bulb of his Thermometers often broke in these Experiments, & that the Mercury sometimes fell suddenly several Hundred Degrees. He likewise found upon Tryal that Ardent Spirits fell 180° below 0 in Farenheits Thermometer. — But I ~~cannot~~ would

beg

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beg leave to observe here that these Experiments
were not altogether conclusive, & that there has been
some Deception in them. For

1st In many of these Experiments related by Mr. Braun
the Bulb of the Tube ~~was~~ broke, by which means some of
the Mercury escaped. From whence it is probable a wrong
Estimation was formed of the Degree of Cold produced by the
Mixture of Snow & Water.—

2dly Mr. Braun tells us that when the Mercury froze
it contracted suddenly & irregularly, & that it always had a con-
cave appearance on its Surface. Now this is the Form which
several of ye Metals assume when they first become cold after ~~&~~
being in a state of fusion, & we know that they all contract vi-
olently when they pass from a fluid to a solid State. But

3dly It is probable that the Mercury never fell far below the
degree of Cold produced, from the Point which
marked, which we said was never lower than the 180° below 0
in Farenheits Scale. Mr Braun moreover tells us that ~~the~~
~~Mercury fell froze suddenly at this point & that 180° below 0~~
it was at this Point the Mercury generally contracted itself.—
From ~~which~~ all which I would Infer that the Mercury froze
suddenly

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suddenly at this Point, & that 180° below 0 was the Cold produced by Mr. Braun by his mixture of Snow & aqua Fortis.

Next to the usefulness of Thermometers in measuring the degrees of Cold; they are usefull in teaching us the Distribution of Heat from one Body to another. Thus supposing you take a certain number of Peices of Metal, & place them altogether, Let some of them be hot, & others cold. In a short time we shall find by applying the Thermometer to them, that they all contain equall degrees of Heat, which we shall distinguish hereafter by the Name of the Equilibrium of heat. But what is this Equilibrium of Heat & do all Bodies contain ~~have~~ an equall Quantity of it? Dr. Boerhaave was of opinion that they did, & imagined that a cubic Inch of all substances, such as metals, Feathers, Air, Water & the like contain'd an equall Quantity of heat in them - His Reason for it, was that the Thermometer pointed at the same Degree when applied to each of them. Mr. Muschenbroeck is of the same Opinion, & ~~that~~ gives the same Reason for it. But a little Reflection will convince us that the opinion is ill founded, for we shall find that a Peice of ~~[illegible]~~ hot Iron

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Iron contains as much more heat, than an equal Quantity of Wood will do, altho' disposed to the same Degrees of heat.—

An accurate knowledge of this Equilibrium of Heat cannot be ascertained by any fixed principles, but is only to be found out by Experiments alone.

A third use of Thermometers is that they teach us to measure the Degrees of Heat in bodies, beyond the reach of the Thermometers themselves. Thus for Instance, by throwing a bit of Iron, heated red hot, into a certain Quantity of cold Water, we may easily find out the Degrees of Heat which the Iron contained. For, by first finding out the degree ~~of~~ & Temperature of the water, & afterwards taking notice how high it raises ye Mercury in the Thermometer, after the Iron is thrown into it, we may tell exactly how much Heat was concentrated in the Iron. In order to do this we must first compute the Quantity of matter ~~contracted~~ contained in the Iron, & then compute the quantity of the Water. If the Iron measures a cubic Inch, we must then find out how many Cubic Inches the water contains, & afterwards multiply the Heat ~~by the~~ we find in ye Water, by the Number of Cubic Inches it was found to contain

and

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and this will give us the exact heat of Iron.

What ~~[illegible]~~ confirms to us the usefulness & certainty of this method of finding out the degrees of Heat in Bodies, beyond the reach of Thermometers, is, that the Experiments made in this way, correspond exactly with some Experiments made by Sir Isaac Newton, with the same View, tho' in a different manner. Sir Isaac's method of determining the Question was as follows. He heated a peice of Iron red hot & when it had cooled a little, he applied the Bulb of a Thermometer to a cavity he had cut out of it, & took notice of the degrees with which it grew cool, & so calculated backwards by which means he found out ~~the~~ (by computing the time Iron took to grow cold) how hot the Iron was when he first took it out of the Fire.

A fourth Use we derive from Thermometers, is that we may by them, find out the time Bodies take to heat or cool, & the different Proportions of heat they receive or lose in given Divisions of Time. In order to ascertain this, 'tis necessary the heating & cooling Causes should ~~[illegible]~~ always be the same, & for this purpose the heated body should be exposed

to

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to a Stream of Air; for when the Air is at Rest, it cannot produce a regular effect upon the heated body, from its receiving such constant supplies of heat from it. You may understand from this, why still Air is much warmer, than when it is agitated, for when it is in a state of Rest it receives Heat from our Bodies, but when it is agitated, ~~for~~ it carries this warm Atmosphere from around us. This fact is so remarkably that we are always apt to think windy weather the Coldest — whereas we ~~cannot~~ are now certain this is not the Case — To convince you of this we shall blow against a Thermometer with a pair of Bellows, & we shall find that it will not in the least, sink the ☿ in the Tube. If any Alteration is produced, the Mercury will rather rise instead of falling, for the heat generated by the friction of the Wind ~~agitated~~ against the sides of the Bulb of the Thermometer, is sufficient to occasion this.

The same way of Reasoning will teach us the Cause why Ice when blown upon by a pair of Bellows melts ~~more~~ much sooner than when it remains in a state of Rest; for by remaining long in one place it cools the Air around it in such a manner ~~that~~ that it dissolves but slowly, whereas the Bellows

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Bellows by driving this cool air from around it, has-tens its dissolution. —

Having now finished our account of the expansion of heat, we shall next proceed to speak of Fluidity, which is the 2d: general effect of Heat.

Fluidity, in all Bodies, is the Consequence of Heat. Many reasons concur to establish this assertion. We find many Bodies which are naturally solid, will always remain fluid while they are warm, while on the other hand many other Bodies, which appear as if Fluidity was essential to them loose it entirely when exposed to the Cold, & put on a solid Form. —

This Observation is very general, insomuch that there are but two or three exceptions to it: Spt. Vini, Æther, & a few of the Subtile oils, are the only Bodies in Nature, that have never yet been brought into a solid form by means of Cold, ~~& [illegible]~~ But we can by no means infer from this that Fluidity is essenti-al to them; We are as yet unaquainted with the low-

est

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-est degrees of Cold, & I have no doubt but that they might be ~~found~~ frozen as firmly as other Bodies, could we contrive a method of robbing them sufficiently of their heat. Mercury was once thought to be a fluid & incapable of putting on any other form, but Mr. Braun (of Petersburg's) Experiments, shew that it may be made solid by means of Cold. —

On the other hand there are some Bodies in Na-ture, such as certain Earths & Stones, which have ~~been~~ never yet been made fluid by heat. — But as we are ignorant ~~in~~ the former Case of the lowest Degrees of Cold, so we ~~[illegible]~~ are Ignorant in ~~of~~ the latter of the ~~hi~~ highest degrees of heat. — It is probable that a Lens might be contrived of such a size & Figure, as would melt even the Hardest Body in Nature, especially if some second matter was mixed with them in order to flux them. —

This Doctrine I am well aware is denied by many of our Modern ~~Phil~~ Philosophers, & in par-ticular by Mr. Mushenbroeck of Leyden, who asserts that

that Fluidity is essential ~~&~~ to Water, & does not depend on the Absence of heat, & that its becoming Ice is entirely owing to some active principle, & frigorific Particles introduced into the water. This Doctrine we hinted at before, but as it is much insisted on by Muschenbroek, an Author of considerable Note, we shall consider each of his Arguments separately, & endeavour to shew the weakness & Fallacy of them. — His Arguments are 13 in Number, of each of which we shall treat in order.

1st He says that water, when kept very quiet below y^e^ freezing Point, will not freeze, but when it is set in Motion by the Air or Wind, it is soon converted into Ice. — From this he Infers, that some foreign Body must have been Introduced into Water, or it would have froze in its Quiet ~~ly~~ State, as the Cold was equally intense in both Cases. Here he forgot what we had said before of the Air receiving warmth from y^e^ water while it ~~was~~ remained unagitated, But of this we shall say more hereafter.

2dly

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2^{dly}. He tells us that he had seen frost continue while the Mercury rose to 36°: & even 41°: in Farenheits Thermometer. The same was observed by Wolfius in Germany & Reaumr in France. It is what each of you may have seen in the Course of Your Observations.

It arrises from the long time which Ice & snow require before they melt. For notwithstanding the Mercury pointed at 36° or 41°. 6 or 8 Feet from the Ground it is very probable it would have stood at 32°: had it been put near the surface of the Earth, for the Air above was probably warmed a little by the Heat of the Sun.

The Nature of a Soil often produces surprising alterations with regard to the slow or speedy Dissolution of Ice or Snow, Upon a dry sandy Soil they disapear in a few Days whereas upon a cold clayey soil they often are undissolved long after the Air has acquired a Temper~~ament~~-ture above the freezing Point.

3^{dly} He says that he saw a great Thaw of Ice & snow when the Mercury stood at 30° of Farenheits Thermometer, which is

2°: below

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below the freezing Point. —

We will not pretend to deny this fact, but we may easily account for it. by supposing either that a very severe Frost had preceded this Thaw, which may have left the Air very Cold, or that the Thermometer was hung to near the Wall, which we know retains Cold a considerable Time, or we may suppose as in the former Case that the Snow & Ice lay upon a warm sandy soil. —

4th He tells us that we often see hoar Frost upon Vegeta=bles — straw & other light Bodies, while we see no appea=rance of Ice upon water. — Those will understand the Reason of this by recollecting what was the 7th Law of the Communication of Heat we mentioned, viz the surfaces & Bulks of Bodies being given they loose or receive Heat in Proportion to the Quality of their Matter — Then soft & slender Bodies show the Frost much sooner than wa=ter from their being so much sooner robbed of their heat. —

5thly He says that he has seen Frost in the months of April May & June after very warm Days & there=fore boldly pronounces that this frost could not have been

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been occasioned by an absence of Heat – But this Ar=
=gument is noways conclusive for such Transaitions
from Heat to cold are very common in most Countries.

6thly He tells us that he has seen Frost in some Places of Europe, while there was no appearance of Frost in ~~many~~ more Notherm Countries. But this was probably produced entirely, by the ~~Variety~~ Vicinity of those Notheren Countries ~~but their was frost~~ to the Sea, which ~~was~~ we observed before, tends to make a Country warm. – –

7thly He says that the quickness with which Ice is produced on water, ~~in one place~~ was proportioned to the Degrees of Cold. But this depends entirely upon the Quick~~ness~~er or slower Motion of the Air. for wind, when very cold, & much agitated, robs water of its heat ~~so~~ much sooner (as we said before) than cold unagitated Air. The Water in these Cases is robbed of its Heat in a Ratio compounded of the Degrees of Cold, & the Agitation of the Air.

8thly He tells us that if you put a mixture of salt & snow over the fire on a plate, & over it put a Plate of

water

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Neat be thy work, let every page be clean; Nor let a blot in thy book be seen

water, the water not ~~withst~~ withstanding ~~quickly~~ readily freezes. In this Case (says he) what can the Ice ~~being~~ owing to? certainly not to the ~~[illegible]~~ absence of heat. — Some active Principles must have been introduced from the mixture of Salt & Snow below. But this is by no means a proper Inference, for the Cold produced by this Composition of Snow & Salt, is so great, that it freezes the water above it long before the fire below can extend its heat to it.

9th Aqua Fortis (he says) when mixed with water produces great heat, but when mixed with Ice produces intense Cold; But Mr. Mushenbruck should remember, that water & Ice are very different Bodies, & that Cold may be evolved, or heat abstracted in the latter case & not in the former, without bringing in the Introduction of frigorific Particles. —

10th He says that we frequently observe no Ice on water during the Night, & yet a little after Sun rise the surface will be covered with thin Crusts of it. — The cold therefore during the Night was not sufficient

for

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for this Purpose, but in the Morning the frigorific Particles were brought into the Atmossphere, & a suffi-
~~cient~~ Congelation immediately ensued. — In answer to this we may Observe that the fact is undoubtedly true, & may be easily explained in the following man-
ner without calling in frigorific Particles. — The Cold during the Night was not sufficient to freeze the Water, yet it was so near the freezing Point, that when the Sun arose, & an Evaporation began to take place a greater degree of Cold was generated, & in consequence of this a Congelation took place. We shall hereafter show the Connection between Evaporation & the generation of Cold. —

11.ly He observes that ~~Ice~~ Ice Water is very hard till it has been boiled a long time, & hence he infers that it contains something in it different from common Water. By Hardness in Water, is meant a property in it, which does not readily admit of its dissolving Soap or boiling Ve-
getables &c. But the same Experiment has been tried by others, & has turned out very differently from what Mr. Muskenbruck relates — The hardness of

Ice

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Ice water is very transitory, & is occasioned by nothing but its Coldness. As soon as you warm it a little, it becomes like water which has never been frozen.

12^ly Mr. Musch^k. informs us, that the Inhabitants of the Alps, from using melted snow are liable to disease called the Guttur turnidum. To this we answer that all those Persons who Drink melted snow are not affected with this Disorder, nor is it observed in other Mountains as in the Andes in South America; where the Inhabitants use snow water as freely as they do upon the Alps.—

13^ly & lastly, he says that all Bodies contract by cold except Water, which is considerably enlarged when it becomes Ice; Now what can this be owing to but an Accession of some foreign Particles to the Water? But we find upon Examination that Ice is no heavier than Water before it froze. Mr. Muschenbruck grants this, & says that the Particles introduced into the Ice are extremly minute, & have little or no Weight. But what shall we say to ~~Iron~~ & Regulus of Antimony which likewise expand in passing from a fluid to ~~a~~ solid form.

Can

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Can ~~the~~ Cooling Particles ~~enter~~ enter into the metals when they are red Hot? By no means. - we conclude therefore that no foreign ~~Body~~ Matter is added to water, or other fluids to make them solid, or taken from them to make them Fluid, & that the presence of heat alone in Bodies is the Cause of their Fluidity. —

There are some Facts mentioned by Vanswieten in his Commentaries on Dr. Boerhaaves Aphorisms which have given much weight to the Opinion of Mr. Meshenbruck concerning the Existance of frigorific Particles. In this Treatise upon that species of Gangreene which is produced by being frost bitten he recommends Cataplasms of Snow & Ice to be applied to the parts affected, & says that they act by extracting the Frigorific spicula from the Body. To illustrate the manner in which they opperate he calls in the Analogy of a frozen apple thrown into a bucket of cold water. Here he says you see the Spicula that are extracted from the Apple lodged upon the surface of it. When these are wiped off, others are again formed there

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there, so that ~~health~~ in time the apple has all its frost extracted from it ~~&~~ regains its usual softness & Taste. — But even these Phænomena however conclusive they may appear can be explained without calling in frigorific ~~Matter~~ Particles.

The Cataplasm of Snow & Ice by their Stimulus in the former Case, rouse the Circulation of the Blood in the Limbs, & by their irritating Quality excite the action of the Nervous Æther, so that all the fluids which stagnated are set in motion without any thing being expelled from them. — The appearance of Spiculæ in the latter Case upon the apple, may be easily accounted for when we ~~re~~ recollect what we said concerning the tendency of Heat to bring itself ~~to~~ to an Equilibrium. ~~The Water in the Bucket being considerably warmer than the apple communicates its heat to it, & thus brings it back to its original taste & softness~~ —

The Apple by its extreme Coldness, freezes the water which surrounds it, & thus gives us the appearance of Spiculæ or frigorific Particles on its surface, while the Water in the Bucket being considerably warmer than the apple, communicates its heat to it, & thus brings it back to its original taste & softness. —

after

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After what has been said, we may venture to consider all the Solid Bodies in Nature ~~tobe~~ as frozen.. Fluidity is their Natural state, which leads me to paint out a Vulgar error with regard to the Cause of fluidity in water. It has gene=-rally been ~~assumed~~ attributed to its consisting of Spherical Globules, & on these its great Mobility has been supposed to depend. Now if this was the Case all ~~bodies~~ bodies in Nature must consist of Spherical Globules likewise, for we can de=-monstrate that all bodies are capable of being made fluid as well as Water-

We shall add here an Observation or two upon that Doctrine of fluidity. –

In the 1. Place we observe a considerable difference between Fluidity & Expansion. The first is sudden, whereas the second is ~~gradually~~ gradual & progressive. There are ~~very~~ many Bodies which appear in an intermediate state between Fluidity & Solidity, as this depends entirely upon one Degree of heat only. Wax, & the different species of Resins are the only Bodies in Nature which assume this intermediate form.

There is a certain point at which all other bodies become solid, & this Point is called the freezing or coagulating Point.

These

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Thus ~~Water~~ Water for Instance we find always becoming solid at the 32°: in Farenheits Thermometer. — These coagulating Points are in general very steady, but they are very Different in different Bodies. —

In the second place I shall here explain a few Chemical Terms to which the Doctrine of Fluidity naturally leads us. Those Bodies which appear solid in the Air, & are ~~altered~~ rendered fluid by heat, & which are changed only in their form, & not in their Properties, are said to be capable of Fusion. — Ice, Salts, & Metals belong to this Class of Bodies. Those Bodies which ~~appear~~ do not assume their former Appearances, but become Smooth, brittle & Transparent, after being ~~transparent~~ made fluid are said to be Vitrified, & the Operation they undergo is called Vitrification. Earths, Stones & some of the Calces of Metals belong to this Class — When Metallic Matter is made to assume this form it is called Scorification. —

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I cannot conclude this account of fluidity without taking Notice of an Opinion of Dr. Blacks Profess of Chemistry in the University of Edinburg; who supposes that Fluidi=ty in Bodies is not so much owing to sensible as to what he calls latent heat. — This latent Heat is formed from sensible heat, & is again converted into it. Thus, for instance, he accounts for the Generation of Heat by the mixture of Water & ~~Sp~~ Vitriolic acid by supposing that the Latent Heat of the water is suddenly converted into the sensible Heat, & on the contrary he supposes that the Cold gene=rated by mixing Aqua Fortis & snow together, is occasi=oned by the Conversion of the sensible Heat of both into Latent heat. — By heat you are to understand a proper=ty of fire, & not the simple Sensation of Heat which belongs to Animal Bodies. This Discovery of Dr. Blacks is recom=mended by the greatest Ingenuity, but as it is somewhat Complex, I shall not ~~engage~~ risque your being put out of Conceit.

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Conceit with our science by delivering it you. The Doctor is now employed in preparing an account of his Experiments upon this subject for the Press, so that you will probably have an opportunity of seeing them related soon in such a manner that the short imperfect account I should give you of them, would only serve to render them uninteligable, or to prevent their affording that entertainment which they ought to do. —— With this we finish our account of Fluidity. We proceed now to treat of. Evaporation which is the 3d. general effect of heat..

Vapor is a light substance like Air & possesses considerable Elasticity. It is capable like Air of Rarefaction by means of Heat, & of Condensation by means of Cold. We have a strisking Instance of the force of heat in producing Vapor from Water. One single Drop of it confined in a Glass Vial, & exposed to a warm fire will burst the Vial with a very great explosion. By attending to this expanding Power in Vapour the Glass makers have made considerable Improvements in their Art.–

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For instead of blowing air into the Glass (which they found required much straining, & of course injured the Lungs) they blow a little spittle into the glass which by becoming Vapor expands the Glass, or metal (as they call it) into any form they Please with a very small Exertion of their Breath — It is upon this account of the sudden conversion of Water into Vapour, & the dreadful Consequences ~~that~~ attending it, that Brasiers take so much Care to prevent Water's coming in Contact with their brass while it is in a state of fusion.

Vapor like Fluidity depends entirely upon heat. by abstracting heat from it it returns again to its natural state. The Degrees of Heat necessary to produce Vapor, are much greater than those necessary to produce fluidity. Bodies differ with regard to the Degree of Heat they require to bring them to what is called the Vaporific Point, some admitting of more & others of less, & this was what gave Rise to the Termes fixed & Volatile

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Volatile. These Expressions are entirely comparative, as no body has ever yet been found out so fixed as to resist the Evaporating Force of Heat – Fluid Bodies pass into Vapour according to the different states of Pressure in the Atmosphere. Water when confined, or strongly compressed by the Air is capable of Receiving a most intense heat without being converted into Vapor. Papins famous Degester is constructed upon these Principles. ~~Here is a Water upon these Principles~~

It is so contrived as to be able to retain Heat enough in it to melt lead, or Tin according to Muschenbroek.

It was first applied by our Epicurees, for the Purpose of Dissolving bodies in order to extract from them a rich Soop. But this Dish not equalling the Expense & trouble of making it has been laid aside for some time. –

The greater the Mechanical Pressure of the Air on any Body, the greater the Heat we may produce on it without its Evaporating. This teaches us, that if we would find out the Natural ~~heat~~ Vaporific Point of Fluids in general

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in general we must have recourse to the Air pump alone where we are sure the Pressure of the Air is always the same. Water we find evaporates at 90°. when the Pressure of the Air is taken off, for the less the Pressure of the Air the less heat is required to make it evaporate. This is still more remarkable in Spt. of Wine which not only evaporates, but even boils when the pressure of the Air is taken from it, with no greater heat than that which the hand, by gently pressing it, gives.

Before we attempt to explain the Cause of Evaporation let us briefly point out a few of the Phænomena which take place in it. If we expose one drop of Water to the fire we find it is immediately converted into Vapor, occasioned by the Heat's coming in contact with its whole surface. If we expose a Quantity of Water in a Bason to the fire we shall ~~not~~ find the evaporation to be more gradual, & that it is carried on by means of the Water's boiling, for the Heat of the Water cannot be encreased

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encreased beyond this Point unless the pressure of the Atmosphere is encreased with it.—

As the Boiling of Water is connected with Evaporation ~~I shall endeavour to account for its Cause~~ I shall here enquire into the Cause of it. Many Theories have been proposed to explain it; such as in the 1.st place that water could contain only a certain Quantity of heat, but this we know ~~from~~ to be false, for Water when con-fined by the pressure of the Air is capable of being heated far above 212.d Others suppose in the second place, that it is caused by the air of the Water being expelled by means of the Heat, but this will not account for the Boilings continuing till the last drop is evaporated; & long after we may suppose all the Air which the water contained dissipated. The true Reason of the boiling of Fluids is simple. The heat we know is always applied to the bottom of the Vessels which contain the fluids. The water imme-diately in contact with the fire is rarified & from its in-feriority in weight to the Water above, it ascends & escapes

in

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in the form of these bubbles which we see upon the Surface of the Water.

I said a little while ago, that ~~that~~ the Vaporific point is much higher than the Point of Fluidity. — But here I must make a few exceptions, for Camphor — Volatile Salts — Sal Ammoniac — & Arsenic will evaporate in a solid form long before they arrive at that Degree of Heat, which is necessary to render them fluid. They even assume the Form of Vapor under the common Pressure of the atmosphere. —

From this, you may easily understand the nature of several Chemical operations, & the meaning of several Chemical Terms such as Evaporation — Distillation & Sublimation — Evaporation is when the volatile Parts of Bodies rise, & leave a fixed matter behind them — Thus Bay salt is produced from salt Water by the Waters being gently evaporated by the heat of the Sun. —

Distillation & Sublimation are the Reverse of Evaporation, & instead of being designed to dissipate the more fluid & Solid Parts of Bodies, are designed to preserve them. — When we operate upon Bodies which produce Fluids

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Fluids it is called Distillation but when we operate upon Bodies which produce Solids ~~it is called~~ the operation is called Sublimation, & the Parts which rise are called Flowers, or Sublimates according to their form. But of this more ~~fully~~ hereafter.

You may learn from this, how Bodies are changed by means of heat, for you here see how the fluid parts of them are set at Liberty. – No Wonder therefore that those Parts, which remain are entirely altered, & that a new combination takes Place among them. –

A very natural Question occurs here as under the two former heads, &(i.e.) is heat capable of producing Vapour in all bodies, as it does Expansion & Fluidity? To this we may reply that Earths are the only Bodies in Nature, ~~that~~ which have as yet resisted the Evaporating force of Fire; even Gold itself which Mr. Boyle (after exposing it two Months to a most Intense heat) pronounced incapable of Evaporation, has of late been made to emit Fumes or Vapor, under the concentrated heat of a burning Glass –

We ~~may~~ are as yet uncertain of the highest Degrees of possible Heat – till these are determined, let us suspend our

Let Ctd

our Opinions & believe that no body in Nature is so fixed as to be Proof against the Evaporating force of Heat. —

The Evaporation which Camphor - Arsenic & the Salts we spoke of undergo, is called Spontaneous. The Vapor which arises from them has no kind of Elasticity. In this respect it differs greatly from the Vapor or Steam of Water, which possesses great Elasticity & overcomes every thing which resists it when it is confined — The ~~fluid~~ more extended the surface of any fluid, is the quicker will be its spontaneous Evaporation. — Thus for Example a spunge when hung up in the Air becomes dry in a very short time from its exposing so many surfaces to the Air. —

I would add; to what has been said already on this subject one Observation more, & (i.e.) when Vapor is confined over water it will ~~produce~~ evaporate only to a certain Degree. It is upon this account that a warm Air evaporates water much slower than Wind which by sweeping off the Vapor from the surface of the water

makes

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makes Room for more to rise. – Vapor is produced al=
=ways by heat – When this is abstracted the vapour again re=
=sumes a fluid form. Thus for Example if you bring a bot=
=tle of Cold water into a warm room where there are a num=
=ber of People gathered, you will soon perceive their Breath, which
is nothing else but Vapor condensed into Drops of Water upon
the sides of the bottle by means of Coldness of the water. –
An appearance somewhat like this depending on the
same Cause may be observed upon the Windows of Bed-cham=
=bers in the winter Season especially if the weather is dry as
well as cold. – You may learn from this the Reason why
Houses & Rocks are often covered with a Frost in the midst of
a general Thaw. For the wind which occasions the Thaw
generally comes from a Warm Quarter & is always filled with
a considerable Quantity of Vapor which no sooner comes in
contact with the cold Houses or Rocks than it is condensed
or converted into frost. We learn hence likewise the cause
of Dew, the ground being warmed by the Rays of the Sun
during

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-during the Day emits a Quantity of insensible Vapor which being chilled by the ~~vapour~~ Coldness that prevails in the upper Regions of the Air, after the Sun is set falls down again upon the Earth in the Form ~~of~~ we per-ceive it. The rising of misty Fogs from low marshy Countries depends also upon the same principle. The Reason why these fogs are so very unwholesome is owing to their being raised from putrid, stagnating Water. This is so fruitful a source of Disorders, that it would afford us much Instruction, could we stop to discuss it in that extensive manner it deserves. In order to understand it I would recommend it to you to inquire in the 1st place how far the Water, evaporated from these fenny Spots of ground acts by its sensible Qualities, or how far by the foreign matters it contains. ~~Out~~ Next endea-vour to find out what the foreign matters are — Whether they ~~out~~ are of an Animal or Vegetable origine or com-posed of both. — How far mixture is necessary to enable them

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them to produce their effects, & lastly what is the State of Putrefaction, or Season of the year, in which they do the most mischief. As these Queries belong to that part of Pathology which treats of the Remote Causes of Diseases, I need not tell you that they are foreign to our present Subject, & come more immediately under the notice of another Professor. We learn further from what we have delivered, the Reason why a Vapor rises from a Hole broke in the Ice in such ~~[illegible]~~ great Quantities, for the Heat of the Water being much greater than that of ye Air above, the Ice causes it to evaporate in this plentifull Manner. —

<u>Water</u> thus evaporated from the Sea, from Rivers & from land is what ~~are~~ afterwards rises into the Clouds which are carried about in the Air & distilled in gentle showers upon the Earth. When this Water freezes in the Air it falls down in the form of Hail or Snow. Such Parts of these ~~as~~ ~~are not~~ are afterwards poured back again, ~~[illegible]~~; ~~again~~ in the Bosom of their Parent Ocean, as are not consumed for the Nourishment of Animals & Plants.

Let

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Let us now enquire into the Cause of Evaporation.–
There has been many Hypothesis proposed to explain it.
Mr. Derham endeavours to account for it by saying that
it is owing, to the Air which is confined in the Water.–
This he infers from waters boiling in an air Pump. These
Particles of Air, he says, carry a thin ~~Fi~~ film of water
into the atmosphere with them in the form of Bubbles.
But this Hypothesis is merely fanciful; for we are
sure that no ~~body~~ bubbles of Water, can be light enough
to ascend in the Air. Mr. Gravesend & Mr. Mushenbruck
have proposed another Solution of the Cause of Evaporation,
& imagine that it is owing to a lesser degree of the same
Heat which makes water boil. This they supposed because
Evaporation was the Natural consequence of waters boiling
– But we cannot admit this opinion, for we are sure
the spontaneous Vapors has no kind of Elasticity, whereas
did it depend upon the same Heat, which makes water
boil, it would be very elastic.–

But there has been a third Hypothesis proposed,
which

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which has in it a greater Degree of Probability than any of those we have mentioned, & (i.e.) that Air acts upon the Water as a menstruum, & this is inferred from the great Analogy which Chemistry affords. This Operation which bodies undergo is called Solution, & de=pends, as we shall show hereafter, upon what is called Chemical Attraction. — Thus for Instance if we expose one drop of Water to the Air we find it is soon evaporated. This they tell us is occasioned by the Air's acting as a solvent upon it. When we attend a little to this Hypothesis will shall find a great Analogy between it, & Chemical Solution. For we find in the 1st place heat tends to dissolve Bodies in proportion to its Intensity. Thus if we put a Quantity of Salt into Wa=ter & boil the water, the salt we shall find will entire=ly Dissolve, but when the water is cooled again, the salt Subsides. This agrees exactly with water which evapo=rates with heat & is again condensed ~~with~~ by Cold. —

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2dly Agitation we know tends to quicken the Solution of Bodies — This we likewise know to be the Case in Water — the more it is agitated by the air the sooner it is evaporated. I might here go on to shew that Evaporation agrees with Chemical Solution in many other ~~Places~~ Particulars, but those which have been mentioned are sufficient for our Purpose. — However specious this Hypothesis may be, there is one insurmountable Objection to it, & (that is,) that water exhales in an Air Pump more than it does out of it. Here we are sure that no Air can be left, to act upon the Water as a Solvent, for the more complete we make ye Vacuum, the greater the Evaporation. — Besides if the Air acted on the Water as a Solvent, it would always dissolve the ~~Water~~ in Proportion to its Density, provided it follows the Analogy of other Chemical Solvents. Evaporation would therefore be greater in Winter

as

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as the Air is most dense at this season. but Experience teaches us that this is not the Case. We may conclude from all this that Air does not act upon water as a solvent, but that it depends on heat alone. It was with reluctance I rejected this last Hypothesis, as it bears so great an Analogy to Chemical Solution, & tends so much to our notions of the Usefulness of Chemistry in explaining the Operations of ~~Chemistry~~ Nature. But facts are stubborn things. It becomes us therefore to admit them even when they tend to overthrow our most darling Opinions. Chemistry above all sciences in the World has nothing to do with Conjectures.

Before we conclude our account of Evaporation, we must take notice that Cold is always generated by it. This was long Observed, but the ~~Discovery~~ Discovery of the Cause of it, was never found till accident led Dr. Cullen to Observe it. As this is a Discovery of some Importance, & great application in Chemistry,

and

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and in Medicine. I shall beg leave to read the account the Dr. has published of it in the 2d Vol of the Physical & Literary Essays of Edinburg. ~~We~~ We shall afterwards illustrate it by the Doctors own Experiments. This Principle of cold being generated by Evaporation is of such great application that we find it a Practice among the Inhabitants of all Warm Climates to cool all the Liquors they use in this Way. In China, India, Persia & Egypt they make all their drinking Cups of a soft porous Clay, which by suffering some of the Water to transude & evaporate cools the Rest. These Cups Travellers tell us are always covered with a piece of Red Cloath, in honour of their God Brama. Mr. Rouelle, a Celebrated Chemist in Paris, has one of them in his Possession, which was given to him by a Physician, who lived twenty years in one of these Countries. So very common is this practice of Cooling Liquors by

Evaporation

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Evaporation that we told there are certain Towns in Egypt & Persia, whose principle Trade consists in making & selling Vessels for this purpose — some of them are so contrived as to be ~~[illegible]~~ suspended under their Horses Bellies where they travel in such a manner, as that the Evaporation is encreased by the motion of the Horses. This Invention must be a particular Blessing in these warm Countries, where they are obliged to pass immense deserts in their Caravans, without ~~[illegible]~~ ever meeting with a Brook or Spring of Water. But the Custom of cooling Drinks is not confined to these eastern Countries alone —

It is practised in the Levant & in many Parts of the West Indies. In my passage home from London in the Summer of the year 1769, I was ~~obliged~~ led by necessity, as well as Curiosity, frequently to try ~~the~~ this Experiment. Upon wrapping a bottle of Wine in a wet Cloath & exposing it for several Hours we always found it considerably Cooled. This succeeded better when the

Wine

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Wine was exposed likewise to a gentle breeze of Wind, for this (as we said before) ~~greatly promotes the Evaporation~~ by carrying off the vapor already formed hastened y Evaporation of the Water. The Cold produced in liquors by these means is always proportioned to the degree of Evaporation which takes place. Upon this account it is always greatest in the Air Pump which we said before greatly favours the Evaporation of the fluids by taking off the Pressure of the Air. Æther evaporates so ~~quickly~~ rapidly in vacuo that it will freeze a Bowl of Water if placed in it the hotest Day in summer. This Experiment has been tried with success by our Countryman Dr. Franklin. —

From what has been said we ~~learn~~ may understand, why low mashy Countries are much Colder than dryer Places. We may likewise learn from this the Reason why a wet floor should be so much avoided, especially while the body is exposed at the same time to the heat of a Fire. Hence we learn also why sprinkling a floor with water or Vinegar in summer time, tends so much to induce a greatful Coolness in it, & lastly we learn why moist Weather

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Weather if continued any time & especially if succeeded by Cold produces so many ~~putrid~~ febrile Disorders; for the ~~[illegible]~~ ~~[illegible]~~ Moisture, by relaxing the body, induces that Debility, which lays a foundation for the cold to bring on Constrictions or a spasm upon the Extremeties of the Vessels. — & this we now know constitutes the proximate Cause of a Fever.

But a Phenomenon still more curious than any we have mentioned may be explained from what has been said concerning the Connection between Evaporation & the Generation of Cold. The heat of the human body in all Climates & in all Countries has never been found to exceed 96° or a 100° of Farenheits Thermometer. But we ~~[illegible]~~ are well assured that the heat of many Climates exceeds these degrees very considerably. The late Dr. Lining of Charlestown tells us in the Philosophical Transactions that the heat in Carolina was often at 126°. & Dr. Shebbiare tells us in his practice of Physic that the Thermometer in <u>Syria</u> a sandy Country in Asiatic Turkey, has often risen to 122°. & that the Inhabitants not only <u>lived</u> during this Excessive heat, but

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but enjoyed ~~perfect~~ a good State of Health. In Order to un-derstand the Reason ~~why~~ of this, we need only remember that the Discharges from the Skin by Sweat & insensible Perspiration, are always proportioned to the Degrees of heat the body is exposed to, & that the Cold generated in the body by the Evaporation of these fluids, will always be in proportion to ~~these~~ their Discharges. This simple Theory explains the Reason why Reapers, & other men who work hard in summertime feel least of the Heat, when they sweat most ~~plentifully~~ profusely. We cannot help admiring the Goodness of the Deity, in this wise Oeconomy of nature, but still however it is connected with a fact, which gives us Room to suspect, that this was not the effect of design, or if it is, that Nature has but half accomplished her purpose — When we take a survey of those Countries that lie within the Tropics we shall find that most of them are, or were originally inhabited by Negroes, & that this part of our Species is confined chiefly to those ~~hot~~ hot Latitudes. — Now had nature intended to have ren-dered the heat of these Countries more tollerable to their Inhabitants

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Inhabitants, she would not have filled them with Negroes, whose Skins expose them them to receive, & feel the heat in a much greater Degree, than White People; but on the contrary would have filled these Regions with Whites, & sent ~~them~~ her tawny Sons as near the Poles as possible. I wish a final cause could be found out for this myste-rious Conduct of Providence. We see so much Design in every Part of the works of Nature that we are obliged to believe that even this too was intended ~~to~~ for some wise purpose. As well mightst a little Insect find fault with a magnificent Palace because it could not compre-hend all its Parts at a single View, as we pretend to complain of the Imperfection of the Works of Nature when we cannot fully comprehend ~~them~~ or under-stand them. —

This Gentn. finishes our account of Evaporation. —

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~~Lect. 9th~~

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Of Ignition _ Lect. 7th Jany. 27th 1771.

We shall now proceed to speak of the 4th general effect of Heat viz: Ignition & Flame, & with this we shall con=clude our Lectures upon this Subject. —

— All Bodies which emit Light & Heat & appear luminous on their Surfaces are said to be capable of Ig=nition. We ~~have~~ have already observed their Expansion. Fluidity & Vapor were produced by Heat. We find likewise that Ignition is produced by it, & that more uniformly, than the other three effects of Heat. It is the same in all bodies _ at all times & in all places. Dr. Martin supposes, that a red hot Iron, is much hotter than a peice of burning Wood, but this is not the Case, for altho' it may contain a greater Quantity of heat in it, yet this heat is equal in both in point of Intensity. In a word all Bodies when ignited con=tain equal Degrees of Heat. It is very hard to tell where Ignition begins, in as much as we are never

able

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able to discern its first Appearance, nor indeed can we tell how great it is, when it is more advanced, for some Eyes see more distinctly than others, & therefore a Diversity of Opinions must always prevail concerning it. We mentioned a Method of determining the Degrees of heat, in bodies beyond the Reach of Thermometers in a former Lecture by placing them in Water – As also a Contrivance for the same purpose invented by Sr. Isaac Newton. –

Either of these methods give us a tolerable Degree of Certainty in fixing the Limits of Heat in Ignited bodies – Sr. Isaac Newton has found out that 635° of Heat were necessary to make Iron ignit, & that when it was heated to the utmost it contained 1049° – This Calculation appears to be pretty accurate, for we know that Mercury requires upwards of 600° of heat to make it boil; so that ~~the~~ Sr. Isaac's method of Calculating may be depended upon as just, as far as we are acquainted with it –

Dr. Boerhaave

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— Dr. Boerhaave says, that Metals are incapable of receiving any further Degrees of heat after they are melted — This he infers from the Analogy of water, the heat of which when unconfined never exceeds that of Boiling Water, but this assertion is altogether Void of Foundation, for Iron which requires the most heat of any of the metals before it melts, is capable of receiving more or less heat. This we prove from its being capable of receiving different Degrees of Fluidity. —

There is not a body in Nature which may not be made red hot, provided it can be kept from turning into Vapor. — Even such as do evaporate might be made red hot provided ~~it can be kept from turning into Vapor~~ we could confine their Vapor. — Water itself we Observed before has melted lead & Tin when confined in Papins Digestor, & the Degrees necessary to do this are but a small Remove from Ignition. The Eolipile which is a brass

Ball

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Ball with a small hole in it, in which a Tube is fixed, the design of which is to answer y Intension of a pair of Bellows to blow Fire. This Instrument I say shews us that Vapor is capable of undergoing a red Heat, & in these Cases where it throws its steam into a red hot furnace, we find it produces a kind of purple Flame, which is occasioned by nothing else but the Vapors becoming ig:
:nited — With this we finish our account of Ignition.

As we have said a good deal concerning the different Degrees of Heat in different Bodies, I shall sum up what we have said upon this subject by subjoining a Table of these differentces according to Farenheits Thermometer.

350° below 0 Mercury fell according to Mr Browns Expt.—
126° spirits of Wine froze according to the same Expt.
120° below 0 was the Siberian Cold we ~~talked~~ spoke of
40 — 0 was the greatest Cold produced by Farenheit,
— this was the Cold admired by Dr. Boerhaave
33°. below 0 weak spirits of Wine froze.
7° — Brandy froze.

130 p

0

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0 — was the Degree of Cold produced by mixing Snow & Salt. —

4°. above 0 was the greatest cold ever felt in England.

20 — 0 Strong Wines froze. —

27°. — Vinegar froze —

32°. — Water freezes & Frost is produced —

65° — is ordinary summer heat —

75° — Sultry weather. —

97° to 100°. is the heat of human Blood. —

108° to 110°. is feverish heat —

118°. Sperma Cati melts. —

142°. Bees wax melts. —

156°. the serum of the blood coagulates — From this you see how little foundation there is, for Dr. Boerhaaves opinion of the serum being coagulated in a Fever. Life could not continue with such a Heat. —

174° — Spirits of Wine boils. —

212° — Water boils. —

208°.

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408° ——— Tin melts. —
460° ——— Bismuth melts —
550° ——— Vitriolic Acid boils =
560° ——— Oil of Turpentine boils. —
585° ——— Lead melts. —
635° ——— Iron begins to shine in the dark according to Sr. Isaacs Newtons Expts. —
750° ——— Iron shines brightly in the Dark —
884° ——— Iron shines in Twilight. —
1050° ——— Iron is red hot & this is the Heat of common Culinary Fire. —

Before we conclude our account of Heat we shall add a few words concerning another effect of Heat which comes properly under this head, (i.e) Inflammation —

Inflammation is by no means so general as the other effects of heat. It is confined only to one

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one Class of Bodies which upon this account are called Inflammables. Every other Class of bodies except these suffer no encreace or Deminution in their Weight from Heat, they receive it & afterwards impart it to other Bodies, & then return again to their usual Form. We shall find upon Inquiry that this is far from being the Case in Inflam: Bodies. —

All Inflammable substances when set on fire, send forth either light or heat, & sometimes both. Part of them we find is consumed ~~with~~ by heat while the matter, which remains behind is so altered as to be incapable of Inflammation. —

This is the Case we may Venture to say with all Inflammable Bodies, without excepting even Spt. Vini & Sulphur ~~which~~ are said to leave no kind of recrementitious Matter behind them.

Dr. Boerhaave

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Dr. Boerhaave considered Spirits of Wine as the purest Pabulum of Fire. But stricter Examina=tion, has taught us, that this is far from being the case, & that even the most highly rectified Alcohol contains a quantity of Water in it. This Water may be condensed by means of a Glass placed over the Spi=rits of Wine while it is burning. Brimstone in like manner after being burnt leaves a quantity of matter behind equal it is said to the Brim=stone itself in weight. Of the nature of this mat=ter we shall say more hereafter. — —

The Principle, which is the Cause of Inflam=mation in Bodies, is never destroyed, but always con=tinues under some new form. It is the same in all bodies, which we prove from our being able to communicate it to Bodies, which have not the least resemblance to them. Thus by adding Char=coal to ⊕ we may form a 🜍. The experiment succeeds equally well if we ~~as~~ add fossil Coal,

Oil,

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Oil - V^{s} - & even some of the metallic Substances to the ⊕ — This Principle is known among ye Chemists by the name of Phlogiston, But as this word is liable to some Ambiguity, I shall substitute in the Room of it, the Term principle of Inflammability, by which I understand the pure principle, which is the Cause of Flame when combined with other bodies, & which is not inflammable in a seperate state — We know but very little as yet, of the true nature of this Principle: —

Whether it is simple or compound, - whether it is the same of the Electric Ether or not — Some Facts, which we shall mention hereafter, give us Reason to think that it is a simple Elimentary Body, & that it is ultimately the ~~left~~ same of as the Electric Ether, & differs from it only by its being differently modified, or combined with other Matters. — It will perhaps surprise you when

I

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I add to this Account of it a Fact which may appear paradoxical, & (i.e.) that it possesses absolute Levity. A Property which has hitherto been denied to matter by all our Philosophers. We said in a former Lecture that Metals become heavier by being Calcined. The Calcination of Metals is nothing else but the seperation of their △. This Principle therefore deminishes the wieght of Metals. What is it then but a principle of Absolute Levity?

Gravitation according to Sr. Isaac Newton depends upon a certain Ether pressing bodies to the surface of the Earth; this is his Explanation of the Term attraction. Now may we not con-ceive of a Matter which counteracts this pressing Quality in Sr. Isaac's Ether? Fire is an evanes-cent Form, it always tends upwards. The Earth is a foreign Country to it. Like water it has a common parent, & as all the various Streams & Rivers

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Rivers, which fertilise our Earth are perpetu-
ally tending & pouring themselves into the
Ocean, so all the ~~particulars~~ particles of light &
Heat or the particles of Fire (of which light & heat
are modifications) After having served some im-
-portant Purposes in the Oeconomy of Nature, seem
as if they tended to their common Origin the
Sun. Should any ~~man~~ One ask, why this species
of matter should tend upwards, while every other
species of matter tends to the Centre of the Earth?
I would answer them by asking them another
Question — Why are the Particles of Water always
in Motion while Earths & Stones stand still? And
why do these Particles always tend one way? —
It is in vain to resolve the Cause of this into the
Form of their Particles, or the Declivity of the
Earth.

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Earth. The same method of Reasoning which explains the Cause of one, will explain the Cause of the other. Nature delights now & then in convin=cing us that altho she moves by Laws, she is not obli=ged to do it. In the present as well as in many parts of our Enquiries, it becomes us to adore what we cannot fully comprehend. — We shall touch upon this subject again when we come to treat of the Cal=cination of Metals. —

— But there is something also necessary besides Heat in order to produce Inflammation &c (i e) Air. Without a constant regular supply of this Principle, there can be no Inflammation. This is a fact so well established in Philosophy, that I shall spend no time in proving it to you, but proceed immediately to enquire into the Reason why Air which has been once burnt will not feed

Flame

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Flame. We are told in general that the Air looses its Elasticity by being burnt. But this is not answering the Question — We mean to inquire how the Air looses its Elasticity. Some tell us that the Air is always loadned with a kind of Vapor, which prevents its feeding flame beyond a certain Degree. That this is not the Case we are ſsure from this, that many Vapors are mixed with Air which rather feed than ex-tinguish Flame. — Besides was such a vapor present in the Air it might easily be condensed by means of Glasses contrived for the Purpose; — but this experiment has been tried without effect. — Others again say that it depends upon a certain matter contained in the Air, which they call the Pabulum Ignis, or food of Fire — This matter they suppose to be of an Acid Nature. Sr Isaac Newton was of this Opinion.

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It was founded on ⦶7 inducing Flame when mixed with Inflammable Bodies in the cold. But we have no Experiments in support of this Hypothesis. It seems improbable that any acid, much less ⦶7 should ever be collected in a sufficient Quantity in the Air, to serve as fewel to Fire.

The Question then has never yet been answered in a satisfactory manner — Was I to offer my Opinion I would say that Air receives something from the Fire, which renders it unfit to feed it afterwards. This something is the Principle of Inflammation of which we have spoken already — It enters into mixture with the Air & forms a third substance of which we shall speak more fully when we come to ~~speak~~ treat upon fixed Air. — The Consideration of this subject will afford us much Entertainment. —

9.

Lect: 7th

I have now Gent: finished the general accounts of the effects of Heat. I have laid before you all the facts I could collect upon this subject, & have occasionally explained to you most of the Phenomina or ~~operations~~ Operations of Nature, in which heat was a principle Agent. Such of you as are desirous of being more acquainted with the Nature of heat may consult Dr. Boerhaave's Treatise upon it. —

— You are now no doubt convinced Gent: how much Instruction & Entertainment the subject of Heat is capable of Affording. It is the grand Principle of Activity in the Universe. — We have shown that Expansion — Fluidity — Vapor — & Flame all depend upon it. We have seen the most solid Bodies in Nature expanded & enlarged by it. So great is this Expanding Power of Heat

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Heat, that some have supposed the swelling of the Earth at the equator to be occasioned by nothing else. Fluidity in like manner depends upon Heat. The Ascent of Vapors in the form of Rain, Hail or Snow are all occasioned by heat. The Flame which warms us in Winter, & which serves so many valuable Purposes in our Kitchens, our Elaboratories, & our shops is produced by heat — It is the ~~same~~ source of Life in Plants & Animals. When ~~it~~ it is withdrawn, Trees drop their leaves, & are soon stripped of all their Verdure — But upon the Return of it they again revive, & appear in all their native Beauty. Animals likewise owe their lives to Heat. Of this we have sufficient Proof in Bats — Swallows & a hundred Insects which lie in a state between sleep & Death during the winter, but upon feeling the invigorating Beams of the

Sun

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Sun in the spring, seem to experience as it were a new Resurrection. Nay it not only recalls life when almost spent from Animals, but often give the first spring to it. Of this we have a remarkable example in the Faecundation of the Egg. This is the offspring of Heat alone. If an Egg is kept in a ~~degree of~~ Heat of 96^d during the usual time of Incubation, a compleat Chick=ken will be formed in it. This was formerly much practized in Egypt but is now become common in many other Countries. How wonderfull then are the Operations of Heat, & how wisely is it regula=ted by the succession of Day & night, & summer & Winter! We cannot too much admire the wisdom, nor adore the Goodness of the Deity, in fixing its Bounds & attennuating its operations. Should the Laws of Gravitation be for a moment suspended & the

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the Earth forget to move in its usual Orbit, how dreadfull would be the Consequence! If She should withdraw herself but a little from the sun, all na=ture would be as it were locked in Chains. Water that Capital Beauty of Nature would cease to flow & never more experience the different Changes. into Vapor — Rain — Hail & snow, which it is perpetu=ally undergoing. Plants would Die, & life itself soon be extinguished in Animals. In a word the Air, & every other fluid body in Nature would become a dense & ~~fixed~~ solid Mass — On the Contrary should the Earth approach too near the sun, the Earth would loose all its Elastic Force. Rivers would overflow their Banks the Earth would be too much parched to afford Nourishment to Plants & Animals & Nature herself would resume her primitive Chaos.

With this Gent. we finish our account of heat. We shall now proceed to treat of the effects of mixture

Lect.

Lett 9th

~~the~~ Lecture 8th.

In our ~~last~~ Definition of Chemistry we said that it was that science which teaches the effects of Heat & Mixture in order to enlarge our Know=ledge in Nature & Arts. We have already consi=dered the effects of Heat. We come now to consider the effects of Mixture —

– The Doctrine of Heat afforded us much specula=tion, & (I hope) some ~~speculation~~ Entertainment. — It abounds with Facts, which lead us to certain general principles from which we explain many of the most secret operations in Nature. —

— The Subject of Mixture is much confined in this Respect when compared with heat. The latter like a mistress is a supreme & necessary Agent in the hands of Nature in all her operations, while the former like a faithful Handmaid, follows close

upon

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upon her Heels, & performs many things in the Oeconomy of the Universe, which are beyound the Reach, or below the Influence of Heat. — Thus we shall show hereafter that Earthquakes are occasioned chiefly by mixture. The Heat or Volcano's, which arise from them, are the Consequence of Mixture. — Many of the ~~Metallic~~ Neutral Salts — & several of the inflamed Bodies are formed from mixture alone, without the immediate assistance of heat.

In a word it is the second active principle in the Universe, & it is difficult to point out a single operation, which goes forwards in Nature without discovering mixture in some form, either in a primary or secondary Way.

In the Works of Art, Mixture seems to vie with heat, in striving which shall be the source of the most useful Inventions. Whenever we turn our Eyes in this Part of the application of Chemistry, we behold a thousand Instances of Mixture taking Place

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Place — Go to the Chemists Elaboratory & you will there see him preparing his Spiritus Mindi. reri — his Volatile Salts — his Magnesia & his prepa=rations of most of the Metals by means of Mixture. Go to the Jeweller — the Bea & all the Artifices who work in Metals, & you will find them as much obliged to a saline mixture which they calls a Flux, as they are to the Furnace, for all the operations they perform upon their ~~their~~ respective Me=tals — Go to the Manufactories of Glass, Porcelain, & all the different species of Earthen ware, & you will find Mixture a principle agent in them all. In a Word there is scarcely a single Art, which has ever been invented by the Ingenuity, or carried on by the Industry of Man in which mixture has not been as active & as useful as Heat. —

The Consideration of the effects of Mixture there=fore, altho' not so entertaining as those of Heat, nor yet so replete with facts, will notwithstanding prove ~~[illegible]~~

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prove useful to us in our future Chemical Researches. — — — — — —

— By Mixture I ~~mean~~ understand in the present Case all those operations in Nature or Art where dissimilar Bodies are united. There is a considerable Variety in the Manner, in which bodies unite together, which has given occasion for the Chemists to specifie them by the Names of Chemical Mixture — Solution & Diffusion, of each of which we shall treat hereafter. — Let us first attend to the genial Phænomina of Mixture. — — — —

— Some Bodies unite Homogeneously, while others unite only for a short time — some generate Heat — others Cold in uniting together — some unite without any sensible Emotion — While others rush together ~~some unite~~ with great Violence, & Impetuosity. We shall illustrate each of these, by an Experiment. 1st If we take a piece of Marble, & throw it into

some

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some ⊖7 we shall find the Marble will dissolve with a considerable Effervescence, but the Liquor produced by this solution will become pure & homogeneous after:wards. —

2dly If we add a little Oil to water & agitate them for sometime, a Union seems to take place, but if we suffer them to stand a few minutes they soon seperate — —

3dly If we take a little of the ⊖7 & add an equall quantity of Water to it, a great Degree of heat will be produced the Instant they are mixed together.

4thly If we add a little nitre to water we shall find a considerable Degree of Cold produced as soon as the Nitre begins to dissolve. —

5thly If we take a small Quantity of Camphor & throw it into some ∇, we shall find it dissolve in:timately without the least sensible Emotion. —

6ly If we take ⊕7 & sps: Sal: Amonon: & mix them together they will unite with great Vio=:lence & Impetuosity, & send forth large white Fumes

Fumes — This intestine Motion is called by the Chemists Effervescence. It is occasioned by the sudden Extrication of fixed Air from the sal: Am:monicac, & its Reduction to common Air. We shall prove this in a subsequent Lecture by an Experiment. We should be carful to distinguish Effervesence from Ebullition & Fermentation — The former is produced by the boiling of Fluids. — The latter is a graduall tendency towards an Assi:mulation of Dissimilar Bodies, attended with a little Noise. & a small seperation of Air. — This is a general Account of the various Phænomina of Mixture. — We said a little while ago that Chemi:cal Mixture, — Solution, & Diffusion, were three distinct species of that general Mixture we have been treating off. We shall now show in what Respects they differ. — It is of Importance to attend to these things. — Without them our Ideas of the Termes & operations of Chemistry, will always be vague & undetermined ——— Of

Lect 8th

1st Of Chemical Mixture

The 1st Circumstance which constitutes a Chemical mixture is that two Bodies only can be united at the same time.

A 2d Circumstance attending Chemical mixture is that the Bodies after mixture posses none of the Properties they had seperately, but form a tertium Quid. A Neutral Salt which is composed of an Acid & Alcali possesses none of the Properties of either, but has certain new Qualities peculiar to itself.

A 3d ~~Chemical~~ Circumstance which attends Chemical Mixture is that there is some Generation of Heat.

A 4th Circumstance which belongs to mixture is that Bodies which were before Volatile or nearly so become more fixed by being united — thus Water which evaporates in a heat far below 100°, when seperate, will not ~~separate~~ evaporate in a Degree of heat above 3 or 400° when united with the ⊕ — In like manner Spt. of Sal ammoniac which evaporates spontaneously

Lect 8th

spontaneously in the open Air when mixed with ⊕ cannot be seperated from it by means of Eva-
-poration. Each of these marks of Chemical Mixture may be liable to some Exceptions, but when taken together they seldom fail of characterising it. The Union of the ⊕ with the Spt. of Sal ammoniac, is an Instance of Chemical Mixture. —

II of Solution. —

Solution is when a solid body is so intimately diffused through every Part of a Fluid Body, that it remains there in a fluid ~~state~~ Homogeneous Form. — The solid body is here called the solvent. — The Fluid in which it is dissolved is called the solvent or Menstruum. The Term Menstruum took its rise from the Ancient Chemists allowing a month for all their Cases of Solution, imagining that this space of time, had some peculiar effect in rendering the Solution Compleate. Here I must take

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Notice that I use the Term Solution in a more extended sense than is common; & apply it to the Union of Fluids with each other. Thus far we ~~Exemplefye~~ Exemplify. We speak of the Solution of Essential Oils in Spirits. But in these Cases it is often a diffi~~cult~~cult matter to determine, which is the Solvend, & which is the Menstruum. When the Quantities of the fluids are unequal the largest may be called the Menstruum & the smallest the Solvend, When the Quantities are equal it is impossible to make any Distinction. –

Solution differs from Chemi~~stry~~cal Mixture in the following particulars. –

1st In Solution there is no Change of Properties produced as in mixture. Thus a hand ful of Salt dissolved in a quart of water continues to be Salt still, altho it is reduced into a thousand little integrant Particles. –

2dly Solution is never attended with a generation of Heat, but for the most part with a generation of Cold.

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Cold. — — —

3dly In solution more than two bodies may be united together. Thus we may dissolve a quantity of Nitre or Glaubers salt, in the same water the common salt was dissolved, & the mixture will still continue homogeneous – The ~~[illegible]~~ Union of the Nitre with the Water as also of the Camphor in the 🜄 are striking Instances of Solution

Solution according to certain differences in the manner of Performing it is called

Masceration,
Infusion
Decoction
Digestion
Circulation
Deliquescence &
Amalgamation.

We shall briefly explain the meaning of each of these Termes.

1st

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1st Maceration is when the Virtues of a sol-
-vend is extracted with a heat below that of boi-
-ling Water. —

2dly Infusion is when a Body to be dissolved, is
~~suffered is~~ suffered to stand upon boiling water
till the Water Cools —

3dly Decoction is the continued application of a
Heat, either above or below the heat of boiling
Water. .

4th When the Heat is less than the boiling
Point it may be performed in open Vessels, but
When it is above the boiling point it should be car-
-ried on in Close Vessels, it is in this last case that
it is most properly called Digestion —

5th Circulation is when the Vapors arising
from one Vessel are condensed by another, & re-
turned again by some Communication into the
first in a liquid Form —

6thly Deliquescence is When a Body is dissolved
by

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by being exposed to the Air, which we know at all times, & in the hottest seasons & Climates con=tains a proportion of Water in it. The Oleum Tartari per Deliquium (as it is called) is prepa=red in this manner —

7th Amalgamation is used only to signify the Solution of any metal in Quicksilver. —

After having found out the method of dis=solving Bodies in general, it remains that we enquire in what manner it may be done with the most expedition. —

1st Bodies dissolve quicker in proportion to their Surfaces. Thus Marble may be made to dissolve more quick by being pulverized, & Metals by being beat into small Plates. The Reason of this is plain; for the more we encrease the points of Contact in these Bodies, the More we accellerate their Solu=tion

2d Solution may be quickened by agitating the Vessel, which contains the matter to be dissolved.

For

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For by means of this a greater Portion of the Menstruum is applied to the solvend, & vice versa at the same time. — Thus for Example V^t poured gently up on water will swim on the surface without any appearance of union, but one shake of the Vessel will so intimately unite them together that they will remain so, for seve-ral years. Count Laraguay an engineous French Chemist, has contrived a Machine for promoting the solution of Bodies by means of Agitation. — The chief advantage of this con-trivance is, that it enables us to dissolve many Bodies in the Cold, which is a matter of great con-sequence considering how much of the Properties of some of them are changed by heat. ~~Dr Ban-croa~~ Dr Bancroft in his natural Histo-ry of Güiana (a book full of curious & ~~entertai-ting~~ interes ting facts) tells us that the Casada, which is a Root used by the Indians of that Country for

Poisoning

poisoning their Arrows, & which is so fatal, that the least Wound with one of them, brings on instant Death; this Root, he says, ~~the Root~~ is so altered by being boiled, that y^e Indians use it for their common food —

3^dly Solution is much quickned by means of Heat — Fire not only hastens the solution of Bodies, but makes the solvent dissolve more of the solvend, than it otherwise would do. Thus cold Water, which dissolves only 1/6 of Nitre, when heated will dissolve a much larger quantity of it. — — How great the Power of heat is in dissolving Bodies may be conceived of, from what we said formerly of Papins Digestare

4^th Solution is quickened by the application of air. Air is so very necessary in Dissolving bodies, that some have supposed, that all Fluids in Nature owe their Liquidity to it. If water saturated with Nitre be put under a receiver & the Air Exausted from it, we shall immediately see

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Part of the Nitre precipitated to the bottom of the Vessel. — If copper is put into a Vial filled with the Volatile Alcali & confined closely from the External Air, the copper will not be affected by the Alcali, but if a free Access of the Air is allowed the Copper will soone be dissolved. There is a third fact which I shall mention, which shews how much Air contributes to promote Solution. If any corrosive body is kept in a Copper Vessel a long time that part only of the Vessel is acted upon where there is a communication between the Air & y^e Contained fluid. — The lower parts of the Copper Vessel is never affected by the matter which it contains. This is what each of you ~~might~~ may have seen in our Kitchens. —

We come now to treat III of Diffusion —

This is sometimes called Mechannical Solution, to distinguish it from the Solution we have just treated off. It differs from ~~the Solution in~~ it in y^e 1.^st Place in having a turbid Appearance. 2^dly in not being permanent. 3^dly In depending entirely

upon

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upon Agitation — — Thus Clay for Example when united with water is said to be diffused in it. By Rest the Clay soon subsides & the Water becomes as clear as ever — The Particles of oil & Water in the Vial before us are only diffused together. The Red Particles of the blood are diffused, not mixed with the serum & Coagulable Lymph in our blood Vessels. This we have not only from Observations made with the Microscope, but from the spontaneous seperation of them, which takes place after blood letting.

— It is of great Importance to have precise Ideas of the meaning of these Termes, as nothing shews ye want of a Regular Education in Physic more than the Abuse of them. As it is by affixing the same Ideas to the same Words that we form a Language by which we maintain our intercourse with one another, so it is by affixing the same meaning to the same Termes that we are enabled to speake or write upon Science with Certainty or advantage — Chemistry has suffered much from Ambiguity in its Termes. Let it be our business to avoid them as much as possible. — Lect 9

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We have breifly pointed out the Phenomina of Mixture — We have explained the meaning of all the Chemical Termes which occur under this Part of the Principles of our science — It remains now that we pass on to speak of what is called the Decomposition of the new compounds formed by means of Mixture —

Of Decomposition. —

When we survey the Bodies before us they appear to be truly homogeneous Fluids. Some of them are formed by means of what we called Chemical Mixture, & therefore possess all the properties we ascribed to Chemical Mixtures — While others of them contain matters so intimately dissolved & united with them, that they appear to possess most of the Properties of simple Bodies. Who would think Notwithstanding this that y simple

Bodies.

Bodies which constitute these Compounds are still the same, or that methods have been found out of seperating these simple Bodies, & procuring them in their Original form, & that these Methods are so uniform as to be reduced to certain Laws of Motion & gravitation themselves — This is what is called Decomposition. It is the source of an immense Number of Operations in Chemistry. It facilitates the labors of the Chemist & makes some of his most simple Processes carry with them the Air of Magic or Inchantment. —

The Decomposition of Bodies is carried on in three ways. — 1st by Precipitation
2d by Evaporation
3d by Chrystallisation of each of which, we shall treat in Order. —

When to two Bodies already united, a third is added, which unites with the one & seperates the Other; the Process is called Precipitation. —

The Body added is called the Precipitant. —

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There are four different Methods of Precipitation

1.st Of the dissolved Body alone — Thus for Example, if to the solution of the Marble in the ⊖7, we add a few grains of an Alcaline salt, the ⊖7 will immediately unite with the salt, while the Marble will be precipitated in the Form of a white Powder —

A 2d Method of Precipitation is of y dissolved Body & the Precipitant. Thus for example. If to the solution of Marble in ⊖7 we add a little ⊕7 the Marble will unite with the ⊕7 & both of them will be precipitated together. —

A 3d Method of Precipitation is of the Menstruum alone — Thus if to a solution of Gold in Aqua Regia, we add ~~the Solution of Gold~~ the Vitriolic Æther, the ☉ will be attracted & suspended by the Æther, while its former Menstruum will fall to the Bottom. I am sorry I am not as yet provided with y Materials for showing you this experiment. It is almost the only Instance we have

in

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in Chemistry of a Precipitation of a menstrum alone. This opinion is often used to determine accurately the purity of Gold, for if any Copper be mixed with it, the Aqua Regia will keep the copper dissolved, & by that means appear more or less of a blue color according to the Quantity of Alloy it Contains.—

A 4th Method of Precipitation. Thus for Example if to a Solution of Camphor in Spirits of Wine, we add a little Water, the V & water will unite, & falls to the bottom, while the Camphor will swim on their surface.—

II Of Crystallization.

This Method of Decomposing Bodies is used chiefly to seperate one Salt from Another.— Thus common Salt is seperated by means of boiling from Salt Petre in the Manufactory of that Article, or it is used to seperate Salts from the Water or other Matters in which they are contained. Thus if we expose a quantity of the Juice of Tobacco Leaves in a cool Cellar

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for a few weeks, we shall find the sides of the Vessel in which the Juice is contained covered with Crystals of the Native or essential salt of the Tobacco, which is for the most part Nitre. –

Crystallization depends either upon diminishing the Heat of the Water in which the salt to be Crystallized is boiled, or upon diminishing ye Quantity of the Menstruum. – – –

III Evaporation

– This is the most simple Method of decomposing Bodies. It consists in dissipating such of their Parts as are most Volatile. In carrying on the Process of Evaporation it is necessary we should avoid too much heat – now & then stir the Matter to be evaporated, & make the surface of it as large as possible. we shall treat more fully of this under the Head of Distillation – – – – – – – –

– It remains now to that we enquire a little into the Reason of the Facts, we have been relating with regard to mixture & Decomposition.

Before

Before the time of Lord Verulam, the Chemists
had but imperfect Notions of this Subject. This
was owing to the very Nature of the Science —
When we explain any thing we endeavour to
make it simple, by comparing with something
which is familiar to us. Thus we find when Sir
Isaac Newton undertook to unfold the Princi-
ples of Astronomy, he had recourse to that Law of
Nature by which a stone falls to the Ground. But
as the Chemists were strangers to every thing but
their own science, they endeavoured to explain every
thing by it, instead of explaining its operatations
by other things. The Principles of Mechanics were
applied to solve most of the operations in Chemistry,
Particularly the Phænomina of Mixture — This
was occasioned by the Notions of Philosophers
being too much contracted, & their speculations
in Philosophy chiefly confined to Mechanics. —
They supposed that all bodies were differently

formed

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formedly & differently agitated, & that this was the reason of that great Variety we see in the Operations of Chemistry. Thus for Example when they found that Aqua Fortis corroded the Skin, they concluded that it contained sharp Particles, because sharp Bodies distroy the skin in like manner. In accounting for the Heat genetrated ~~per the~~ by mixing ⊕ & water together, they tell us further, that the ⊕ is a dense earthy Body full of Fire & that the water by diluting the ⊕ sets this Fire at Liberty, & thus produces the Heat we Observe — Here they take it for granted that Heat consits in Particles — that the ⊕ contains them, but they are so invelloped that they cannot act untill they are diluted with water. But how will they account for the Generation of Cold from the mixture of Ice & the ⊕ — The Ice when dissolved dilutes the the ⊕ as well as the Water. This one Fact is sufficient

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sufficient to show us that the whole of their Theory is fanciful, & altogether void of Foundation —

— With Regard to the Solution of Marble in ⊖7, they tell us that it depends upon the ⊖7 having certain spiculæ or needles in it, which are constantly agitated, & which by entering into the Pores of the Marble dissolve it. This Notion is equally groundless. For in the First place they take it for granted, that there are certain spiculæ in the Salt, which is merely Hypothetical, & 2^{dly} They suppose that they are always agitated in the same manner that we perceive the Air to be with those substances which float in it. But this ~~other~~ motion in the Air is produced by Animals breathing in it, & many other Causes, which we cannot suppose to have the least action in any other Fluids. — Besides if the Action of these Acid Salts depends upon spiculæ, how will they account for Aqua Regia's

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Regia's dissolving Gold & not Silver, & aqua Fortis dissolving Silver & not Gold? — The Spicula are y same in both Cases. — — — — — — — —

— Several other Theories have been proposed to explain the Cause of Solution or mixture, but as they are all built upon mechanical Principles, I shall not trouble you with a Detail of them. — We are indebted to Sir Isaac Newton for an Explanation of the Cause of the Phenomina we have been treating off. This ~~illustration~~ ious illustrious Philosopher made considerable Discoveries in Chemistry. — He first found out that the Revolution of the Heavenly Bodies depended on what he called _attraction_. — He Observed the effect of this Power in the Magnet — in capillary Tubes — & in Electricity. — He saw it likewise in many small Bodies which attracted each other with great Force. Thus for Instance two pieces of Marble when well polished will adhere firmly together even in Vacuo where

their

their adhesion cannot be supposed to arise from any pressure in the External Air. After having observed these things carefully he began to suspect that all ye Phænomina of Mixture were owing to the same Principle of Attraction. You may consult his opinion upon this subject at large in his 31st Query annexed to his Treatise upon Optics. The Substance of it is as follows. 1st when any two fluid Bodies unite together in Mixture or Solution it is owing to a specific attraction between them. 2dly when a solid & fluid Body are united it is likewise occasioned by a particular attraction between them. 3dly When a Volatile body is united to a fixed one it is difficult to seperate them. The Volatility of the first is repressed, by being combined with the last. This is occasioned by their strong & close attraction to each other. 4thly When a third Body is added to a compound of two & a seperation of a thereby produced of one of its constituent Parts to which the third

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third Body afterwards unites itself, it is owing to a greater attraction between them, than between the two Bodies formerly united. —

— This a Short Account of Sir Isaac Newtons Theory of Chemical Attraction. From its simplicity it soon gained the Consent of most of the Philosophers of Sr. Isaacs time. There is however one ~~of~~ or two Faults in it — Thus he supposes that the Effervence which happens between two heterogeneous Bodies when united such as of an acid & an Alcali, is occasioned by the Collision or Attribution of the Particles of each against one Another. — —

— In like manner he supposes the heat from Mixture depends upon ye same Cause. But later Observations have taught us that this is not the Case, for we now know that Effervescence depends upon an Elastic substance being set at Liberty from the effervescing Fluids, & we see cold

as

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as often generated as Heat even by the most violent Collision of Bodies. Sir Isaac Newton does not attempt to explain the meaning of this Attraction. — He only relates it in the most simple Manner. — The Term he uses viz: Attraction is certainly a good one, & much better than the word *affinity*, which is used by Maquair & most of the French Writers — — *Affinity* supposes a Resemblance in the bodies which are united, Whereas we see many of them unite together, such as Silver & Aqua Fortis — Gold & aqua Regia — & many others which have not the least Resemblance to each other. — The *Germans* as well as the French were averse for some time to this Theory. This will not surprise us when we consider that they are an industrious People, & Delight more in collecting Facts & making Experiments than in deducing Principles from them. *Dr. Friend's Chemical Lectures* which were published

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published about this time retarded the spreading of Sir Isaac's Theory for a little while, but it soon overcame all these Difficulties by its own native simplicity, & it is now universally embraced by all the most noted Chemists in Europe.

I go on to add a few Remarks upon this species of Attraction —

1st It differs from the Attraction of Gravitation — Cohesion & Magnetism, inas much as it never disposes large Bodies to unite, which are not in Contact with each other. ~~& they will then incorporate intimately together with the each other~~. Thus salt will never dissolve in Water, while it lays at any Distance from it —

2dly It reaches those Bodies only which are in the Closest Contact. Thus we find Mercury & ♃ will not unite when only applied to each other. But if they are ground together for some time, all the Particles of each will be brot into Contact, & they will

will then incorporate intimately together —

3^dly ~~It takes~~ It cannot take place between two solid Bodies unless they are reduced to a ~~solid~~ fluid state either before or after their Mixture. This may be illustrated by a very simple Experiment — If we take a little Sal Ammoniac, which is compounded of ⊖7 & Volatile Alcali, & an equal quantity of Salt of 🜿 & mix them together, we shall perceive no Alteration in Consequence of this in respect to their smell, but when we add water to them, & thus reduce them to a fluid state, they immediately unite & act upon each other, This is manifested by the strong Volatile smell which it sends forth, which is occasioned by the Volatile Alkali being set at liberty from the Union of the ⊖7 & fixed Alkali together — —

4^ly The Minuteness of the Atoms which are formed by this Species of Attraction go almost beyond Conception. We shall illustrate this

41 42.

remark

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remark too by an Experiment — If we take a single Grain of the Salt of Silver (or Lunar Caustic as it is called) which is prepared by Dissolving silver in ⦶7, & put it into a Glass of clean Water. The salt will soon dissolve so intimately that no appearance of Turpidness can be seen, But if we add a little ⊖7 to it, it will show us that this minute Quantity thro' every Part of the Water. — by its becoming imme=diately turbid — This is owing to the 2d. Method of Precipitation taking place (i.e.) to a union of the silver & ⊖7 together. —

— When one Body is dissolved in, or mixes with another, it is called simply by the Name of Attraction. —

— When a third body is added to a Compound compo=sed of two simple Bodies & unites with the one, while it seperates the other, it is called Elective attrac=tion. — Why dont all the three Bodies unite toge=ther? & why is a seperation of one of them produced by the addition of a third? While there is an Elec=tive Attraction, between two of them, there must

be

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be certainly something like a Repulsion between one of these, & the Body which was added. —

— The Order in which Bodies in like Circumstances attract each other is so invariably the same, that the Chemists have contrived tables for shewing the Relation which they have to each other. Mr. Geoffroy was the first who attempted any thing of this kind. But the Table contrived by him was by no means so perfect as we could wish. Some have complained that he has not arranged the Objects of Chemistry properly. — But some Allowance must be made for Bodies not attracting each other invariably in the same manner at all times. — Thus their Attraction to each other, differs according to the Degrees of Heat, we employ in uniting or Decomposing them, especially if one of them is Volatile. This Deserves to be well attended to, & will explain many seeming Contradictions in Geoffroy's Table — You may see this Table

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Table in Mâcquairs Chemistry. I have set down the Objects of Chemistry nearly in the same man=ner as Mr. Geoffroy in the table of Elective Attrac=tions, which you find in the 28th page of your sylla=bus, you may understand the whole of it from hea=ring the ~~[illegible]~~ first Column explained. —
The ⊕ attracts Δ the most powerfully of any sub=stance in Nature — Next to this — the fixed alkali, Next Calcareous Earths & so on of all the Rest —
Its attraction to Volatile Alcali & the Earth of Alum, are exactly the same so that y latter will not Decompose the former. To point out this, I have enclosed them in a mark to denote their Equality in this Respect. If the ⊕ is united to any of the substances below the Δ, the Δ will attract it more powerfully & so decompose it —
If ⊕ is united to any of the substances below fixed Alkali, the fixed Alkali will seperate it &
so on

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so on of all the rest – You will see the propriety & usefulness of this Table more fully in the Course of these Lectures, when we come to treat of the Chemi-cal Operations.

But again – When a Compound of two Ingredients is added to Another Compound of two Ingredients – If one of the Ingredients of the first unites to one of the Ingredients of the last, & if after this, the two Ingredients which remain unite together it is called

Double Elective Attraction –

– Thus for Example, if we add a solution of Sal Martis or Copperas (which is compounded of ~~Lead Vinegar) a double Electiv Attraction will take Place~~ Iron & the ⊕7) to a solution of Saccharum Saturni (which is composed of Lead & Vinegar) A double Elective Attraction will take place – The ⊕7 having a stronger Elective Attraction to the Lead, than it has to the Iron, & vice versa as you will see in

the

Leith 9th

the 9th Column of ye 20th Page of our Syllabus, unites with it, while the Iron Unites with the Vegetable acid, & thus two new Compounds are formed. In the 30 or 31st Pages of your syllabus you will find several of the Princip~~al~~al Cases of double Elective Attraction set down. By explaining the first of them you will be able to understand all the Rest. Suppose an acid of any kind united to common Earth or Metallic Substances & a fixed Alkali (which we shall show hereafter to be composed of a simple Alkali, salt & fixed ~~Air~~ Air) should be mixed together what will be the Consequence? — Look into the Table of single Elective Attraction, & you will find that all the acids attract fixed Alkali much stronger than they do any of the Earths or metallic substances. — The fixed Air likewise the Earths more powerfully than it does the Alkaline Salt — a Double Elective Attraction must of Course take place, & two new Compound will be formed which will be different according to the Nature of the Acid, or Earth — or Metallic substance

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-stance we employ. We shall explain all the other Cases of double Elective Attraction hereafter by pointing out the particular Operations in Chemistry which they refer to. —

— With this we finish our account of Mixture. — I shall just add one single Fact more to it. which altho' of no great Importance, may lead to some useful Specu-lations — The Fact is this. — If two bodies are uni-ted together their bulk & weight will be different from what they were when seperate. In some the Bulk is more, in others less — Thus salt when added to Water deminishes its bulk considerably. This by the by fur-nishes us with another Argument of the Fluidity of water depending upon Spherical Particles, which are ultimately solid, for if this was the Case, they could not be compressed into a less bulk & still retain their Fluidity. — Some become lighter by mixture, others heavier, such as the Metals in particular. Thus for Example an Amalgamation of Mercury & Silver are always heavier than they were when seperate.

Mr. Rameur

Mr. Reaumur (of the French Academy) has treated largely of this subject, & has illustrated one species of it by a very familiar Experiment. He took a Cylindrical Vessel like a Thermometer & filled it half full of Water & afterwards added by Degrees a quantity of ∇ (which is lighter than the Water) so as to fill it to the Top. After inverting the Tube & suffering it to stand a while, he found the Liquor stood much lower than when the two were first mixed together - It is sometimes necessary to suffer it to stand a little while in Order that the Heat acquired during the Operation may be dissipated, for Heat we know tends to expand fluids considerably - ~~from their specific gravity when~~ From this Experiment It appears that we cannot tell the Purity of any substances from their specific Gravity when they are in a compound state. This finishes our account of Mixture. We shall proceed according to the Order of our Syllabus to treat of the Chemical Apparatus.

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Having now finished our general Account of the Effects of Heat & Mixture, we shall proceed in the next place to treat of the Chemical Apparatus

§ III. Of the Chemical Apparatus.

This Altho' not the most entertaining, is certainly a very important Branch of our Course. A know=ledge of the Form ~~&~~ use of Chemical Vessels is abso=lutely necessary to the Chemist — Without this he will never be able to conduct the operations of Che=mistry properly, nor will he dare to speak or write upon them with~~out~~ that Confidence he would wish to do. Let me therefore beg your attention Gentlemen to what we shall say upon this subject. I shall en=deavour to illustrate the whole in as concise, & at the same time in as clear a manner as possible. —

Under the Terms of Chemical apparatus, I intend to confine myself entirely to those Utensils which are

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are necessary to perform Chemical Operations. —

— The Instruments or Utensils of Chemistry are divided into three general Heads. see the Syllabus.

— We shall treat of each of these methods of producing Heat in the Order we have mentioned them —

— The 1.st viz: the Heat of Animal Bodies is only used to regulate Thermometers. It is usefull in this respect upon the account of its being so nearly the same in all Climates & in all seasons of the ~~Earth~~ Year —

— 2dly The Heat generated by the Percussion of solid Bodies against each other is used cheifly for the common purposes of Life such as kindling fires — setting fire to Gun Powder & the like. It is but seldom used in Chemistry because it is so very transitory —

3dly Electricity has been but little used in Chemistry, & that for the same Reason. Metals are sometimes acted upon very powerfully by it. It not only brings them into a state of fusion but it has of late been employed to revive them after they were

Calcined

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calcined, & to bring them back to their Metallic State.

The 4th Method of producing heat, Viz: by means of Mixture is likewise so transitory that it is seldom employed in Chemical Operations. —

5th There is a very considerable that produced in Fermentation. We shall enquire into the Cause of this Heat, when we come to deliver the Chemical History of Vegetables. — At present we shall only observe that it is much used in Chemistry in those Cases where a long, slow, uniform heat is required. It was formerly used in many Operations of this kind. The common Method of Expressing this operation, was to "put the substance to be digested into the Horse's Belly" because Horse Dung was chiefly employed for this purpose. It affords a heat of 120d. According to Farenheights Thermometer. The heat of Fermentation is like-wise much used in promoting Vegetation, & in hatch-ing of fowles. In the former Case Oak bark which

has

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~~been~~ been used in Tanning is ~~the~~ generally employed.
~~the Method of Procuring Heat viz by means of mix-
ture is deserving of transmitting~~ —
— This is put into Green Houses in large deep Beds, where it generates a heat, which continues for several Weeks. A Gentleman in England sometime ago puzled his freinds by saying that he would Raise Melons with-out Earth — water — or Dung. — The manner in which he did it was by planting them in beds of Oak Bark. The matter used in the latter Case viz in the Hatching of Fowles generally consists of the Dung of Ani-mals — The Eggs are placed in a Drawer with a quantity of Dung above & below them. A Thermometer is put into the Drawer with the Eggs to regulate the Degrees of Heat. The Dung is changed two or three times during the Incubation; during which time warm Ashes are placed above & below the Eggs till the Dung begins to ferment a little. I had the Pleasure of seeing a contrivance made for this purpose by a Gentleman in Paris who shewed me at the same time several large fowles that were

hatched in this Way. —

6thly. The Heat of the Sun is obtained by exposing Bodies to it. It is called by the Chemists Insolation — This heat is pretty uniform, & is much used in extracting the Virtues from Gums — Roots — Bark & the like. It may be much increased by means of Burning Glasses — These were first introduced into use for this purpose by Archimedes, who employed them in setting fire to the Enemies Ships, which besieged his Native City. — — This Story has long been regarded as fabulous, But Mr. Buffon (of the French Academy) has proved the truth of it by succeeding in an Experiment of the same nature. — He blacked a peice of Wood with some Pitch, & afterwards set it on Fire by exposing it to the Concentrated Rays of the Sun collected in a large burning Glass. Mr. Buffon relates that he made Gold emit ~~flame~~ Fumes by being exposed to the Focus of one of these Glasses. —

The 7th Heat of Fewel is that which is the most employed by the Chemist in all his opperations. Fewel may be divided into 6 different Species —

1st — Fluids.
2d — Peat or Turf.

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3^d Charcoal of Wood.
4th Fossil Coal ~~[illegible]~~ charred - called also Culm. -
5th Wood & crude fossil Coal -
6th the Dung of Animals. -

1st Fluids are capable of burning only upon a wick, & are used when a small regular Degree of Heat is wanting - ∇ & Oil are the only 2 in Nature which are employed for this purpose - The Flame produced by ∇ may be made greater or less by the number or size of our Wicks. - The Heat of the ∇ while it is burning never exceeds 174°. - While the heat of the Flame is equal to that of a flame ~~[illegible]~~ from any other fewel - Oil likewise burns upon a Wick. But does not produce so pure a flame as ∇ - It is apt sometimes to burn the Wick which prevents a proper Absorption of the Oil. - To remedy this a substance we shall speak of hereafter called the Asbestos, & fine Silver Rods have been twisted together & used for Wicks - They answer much better than Cotton. Besides this the

Oil

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Oil when burnt, leaves a Carbonaceous matter behind it — for which Reason it is greatly inferior to pure V in all those Cases where we would wish to employ this kind of heat. —

2^{ly} The Peat & Turf are soft spongy Substances, & are used when we want a cheap gentle fire. D^r. Boerhaave was fond of employing this kind of fewel which he calls his "fornax Studiosorum" for some of the lesser Operations in Chemistry. they contain a considerable Quantity of Water which tend to deminish their heat.

3^{ly} Charcoal of Wood kindles very easy, & leaves but little ashes behind it, & those so very light that they are easily blown away by the Air. The Heat produced by this fewel is very intense. It is this fewel alone which we propose to use in all ~~the~~ our Operations in the Course of these Lectures. It is liable to one Inconvenience only & that is it requires such frequent additions of Coal to keep up the heat that a great quantity of it is necessarily consumed —

4^{th} Fossil coal charred, has nearly the same proper=
=ties

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-ties ~~of dense Inflammable matter, & in being~~ as the Charcoal of Wood, but it is superior to it in somethings, particularly in containing a greater proportion of dense Inflammable Matter, & in being consumed more slowly. It leaves a considerable Quantity of Ashes behind it which are apt to Vitrify & clog the Furnace. However this may be prevented by proper Care. – This charred fossil Coal is made by burning the common fossil Coal pretty much in the same manner as we do wood in this Country. It is called Coke or Culen in England, & is much used there by the Malters for Drying their Malt. They value it not only upon the account of its intense & regular Heat, but upon the account of its emitting no smoke – A Circumstance which tends much to give that great superiority to the British Malt above all the Malt in the World –

5th Wood & crude Fossil Coal are distinguished from the former Coals by emitting a vivid flame, & by having a greater Quantity of Water & saline matter mixed with them.

These

These Watery & saline Particles are converted into Vapor by Means of the heat. This Vapor by uniting with the △ occasions a great deal of Smoke. If the Heat is urged a little this heat is converted into flame which has its uses in Chemistry. The most intense Heat in the world is produced by means of Flame. It is chiefly used in smelting of Iron, & in all those Cases where we would not chuse the matter upon which we are operating should not come in contact with the Fire. The more we confine the smoke, the greater & more intense we render the flame.

6thly The Dung of Animals is used but little in Europe, either for Culinary or Chemical Purposes, but in Asia it is much used for both. It contains a quantity of Oil & sometimes a quantity of indigested, or unchanged Vegetable substances which abound with △. It was a Custom among the Jews, & is still common in many of the Eastern Countries to preserve this Dung in sheds appointed for this Purpose, near their Dwelling houses in Order to keep it constantly dry. Hence we may understand

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understand the meaning of an elegant Passage in scripture called "embracing the Dung Hill" — It supposes that persons were so poor & so destitute of Habitation, that they were glad to lie down upon the Dung Heapes in order to secure themselves from the Inclemencies of the Weather by the shelter which they afforded. —

— We proceed in the 2d place to speak of the Properties necessary to forme Chemical Vessels. — In our Choice of Chemical Vessels we should endeavour to procure such as have the following 5 properties. —

— 1st They should be transparent —

— 2d They should be composed of such materials, as the solvents will not act upon —

3dly they should bear the sudden Vicissitudes of Heat & Cold. —

4th they should be strong, & made so close as to confine the steam. And

5th They should bear the most Violent heat without melting —

Hitherto we have not been so fortunate as to find out any substance which possesses all these Properties.

We

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We are therefore obliged to select as many of them as we can. —

Glass Metal — & Eathen Ware have generally been employed for this purpose. The Glass has the two first properties we mentioned — it is transparent — & is not acted on by any solvents that we are acquainted with — But then it wants the other three, (i e) it will not bear y^e sudden Vicissitudes from Heat to cold — & it is apt to melt in a great heat. Van Helmont tells us that he had found out a method of Obviating this last Inconvenience in glass, by a particular kind of Coating, which he has contrived, ~~which~~ that enabled it to endure the most intense heat without melting — ~~With~~ what this Coating is, he does not tell us. I only mention the Fact, to show you the possibility of such a substance being contrived — It is often ~~of~~ use to mention those things which are not known in a science. The thinner Glass Vessels are

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are made the better, as they become by this means more flexible & less apt to be broken. There is like-wise an Advantage in having them of a spherical Figure, which enables them to receive the Heat in a more equable manner. — Before they are used for any operations in Chemistry they should be well Ana-nailed - (i e) they should be exposed for sometime to a slow Fire after they are blown. Why this slow Fire should harden the Glass in such a manner we cannot pretend to say till we are much better ac-quainted with the Nature of fire. —

— A 2d Substance employed in making chemical Vessels is the Metals. They bear the Vicissitudes of Heat & Cold - & possess great strength — But they are not transparent. They are likewise apt to melt in an intense heat, & are easily corroded by a great number of Solvents. This is y^e Case in a particular manner with Iron & Copper unless they are well tin-ned, & even thus they are apt to be corroded. Silver &

Gold.

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Gold resist the action of most of our Solvents - but these metals are too costly to be employed in large operations. -

3dly The Earthen Vessels endure the most intense heat without melting, but they want all the other necessary Properties of Chemical Vessels - Some kinds of Earth I grant are not easily corroded by any of Solvents. That Clay is best fitted for Chemical purposes which is most durable when moist, & which becomes most solid & dense when it is baked. - The Sturbrige wares & the common Pipes are made of a Clay of this kind. It is a great advantage to these Vessels to have a little sand added to them - This renders them less brittle & enables them to endure much greater Degrees of Heat that the Clay alone is capable of enduring. -

Of The Form of Chemical Vessels -

The Form of these Vessels is different according to the Nature of the Operations we perform in them. - You may remember when speaking of

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of Chemical Attraction, that we said it was necessary Bodies should be made fluid in order to their being mixed together — Therefore all chemi=-cal Vessels are adapted to Fusion — Evaporation — & Solution — & their form will be different accor=-ding as they are ~~adapted~~ designed for either of these Purposes —

Of Fusion. —

— Fusion combines Bodies by what is called dry Solution, or seperates them either by means of an elective Attraction, or the Action of Fire. —

— When an Elective Attraction takes place un=-der fusion, the Operation is called a Precipitation by Fusion — The part which is seperated is ter=-med Scoria, or more commonly Regulus, owing to its connecting in the form of a little Crown — To illustrate this kind of elective attraction let us attend a little to the common process for

purifying

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putrefying <u>Crude Antimony</u> - This substance is composed of 🜍, & a pure metal substance called a Regulus, because it is only obtained in this Form. It is required to seperate the 🜍 from the Regulus. To accomplish this what must we do? - Look into the 4th Column of your Table of single elec:tive Attraction, & you will find that <u>Iron</u> has a much stronger Attraction to 🜍 than the Regulus has - Let us therefore add some Plates of Iron to the ♁, & a little Alcaline salt to promote its Fusion, & expose the whole to an intense Heat, and we shall soon find that 🜍 will forsake the ♁ & unite with ♂, while the metalic part of the ♁ will fall to the Bottom in the form of a <u>Regulus</u>

To illustrate the second method of seperating Bodies in fusion viz: by the <u>action of Fire</u>, let us suppose a metallic Mass composed of copper & Lead, exposed to a degree of heat just sufficient to

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to melt the lead — the Lead will be fused & run out while the Copper ~~while the Copper~~ will remain behind unchanged. This is one of the methods by which silver is purified from its mixture with Lead. — The Operation is called Eliquation. Conge=lation is the reverse of Eliquation, but they both depend upon the same principles viz: the differ=rent fusibility of Bodies — Thus if a degree of heat below 30° be applied to a mixture of Alcohol & water, the Water will soon be converted into Ice, while the ∇ or alcohol will still remain fluid upon the account of its greater fusibility There are several other Terms such as Scorification, Ca=pellation & Reduction which occur in treating of the Vessels necessary for Fusion. But these will come in more properly when we come to deliver the Chimical History of the Metallic Substances. The Vessels employed in Fusion are either

(a) Crucibles or

(b) Coppels —

Crucibles are generally composed of Clay & sand, &

are

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are capable of enduring the most violent Heat.—
They are of a Conical Form, & are narrow below &
wide above; The Metal when melted is determined
better by this form, towards the bottom of the Cruci=
=bles. They are sometimes made of a Triangular form
for the sake of powring the metal out more easily
into another Vessel; but this is of little Consequence
as we mostly suffer the mettal to cool & then break
the Crucible in order to come at it. One Crucible is
generally used to cover another to defend the matter to
be operated upon from the external Air, & from com=
=ing in contact with the fewel. But a cover of any
other Contrivance would answer equally well.—
There is a sort of Crucibles made of black lead & Clay
which are much used by the Metallurgist or workers
in Metals.— These are greatly superior to the others
in strength; & endure the most intense heat without
breaking. But they are apt to be fluxed when any
saline matter comes in contact with them.—

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It is a good method to inclose one Crucible in another the ~~Heat~~ Heat is thus received in a more equable manner. I must here take notice that Mr. Lewis has contrived a new form of Crucibles somewhat different from the conical ones we before spoke of, which answer all the purposes we could wish for. They are provided with a neat cover. We must always brake them in order to procure the Matters we want from them.

The Coppels are composed of the Bones of animals. Cranmer has wrote pretty fully upon the method of making them. He directs us to make use of all kinds of Bones except those of swine. The bones of fish he prefers to all others. They should be calcined till they assume an uniform whiteness, & afterwards they should be ground & sifted. After this they should be well washed in order to dissolve all the salt which the fire extracted from them, for this by remaining in them would be apt to make the bony matter vitrify some especially when lead comes to be mixed with them. They are made to stick together by a little Water, or what is much better y white of an Egg mixed with a little water.

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W T F - S. - D
8. 9 - 10. 11 - 12 —

Quig Jn:
Love Saml.
Walker Benj.
Evans Jno.
Farren Wd.

These three Things

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We come now to treat of these Chemical Vessels which are employed in Evaporation. These are -

(a) Such as dissipate the Volatile parts of bodies & retain the fixed — These are employed only in the most simple ~~Oper~~ Operations. They are generally open above — Common Earthen Pans are frequently used for this purpose. Extracts from the Juice of Plants are prepared in this maner. —

a (b) sort of Chemical Vessels which are used in Evaporation, are such as are designed to retain the evaporating matter. They are employed in Distillation & Sublimation according as the matter we evaporate is fluid or solid. This kind of Distillation & Sublimation is generally carried on by what ~~Chemists~~ is called Addition. — The Addition serves the following purposes.

1. By Means of an Elective Attraction, ~~it lets loose~~ it lets loose a Volatile part & retains a fixed. Thus in distilling the ♈ from Nitre we add the ⊕♈ which from

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from its ~~double~~ stronger Elective Attraction to the alka-line basis of the Nitre unites with it while the ⦶7. is set at liberty & rises in the form of Red Fumes.

2^{dly} By means of an Elective Attraction, Addition serves ~~to~~ to fix one of ~~the~~ two Volatile Parts of a body. Thus if we add ⊕7 to Sal Ammoniac: (which is com-posed of Volatile Alkali & ⊖7 which is likewise vola-tile ~~it appears~~ in a certain Degree of Heat) the ⊕7 will unite with the volatile Alkali, & fix it in such a manner that it cannot rise. — or if we add a fixed Alkali to the Sal Ammoniac, we shall detain the ⊖7 & suffer the Volatile Alkali to rise alone.

3^{dly} By Addition we seperate a fixed part by Volatilizing it. This likewise depends upon an Elective Attraction. Thus suppose I want to de-compose crude Antimony so as to procure its Regulus free from its 🜍. What Methods shall I take to accomplish it? By adding ⊖7 to it. This unites with the Regulus of the ♁, & rises with it in

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in the Form of a soft greasy substance called from hence the butter of ♁. The 🜍 may be detained behind by adding a little Mercury to it — There is a method of volatilizing the Regulus by means of a double elective attraction.

Thus suppose you add as in the 10th Case of double Elective attraction page 31st — (which please to see in the syllabus) I say suppose you add to crude ♁ (which you now know is composed of 🜍 & Regulus) an equall quantity of Corrosive sublimate (which is composed of ☿ dissolved in ⊖7) the ⊖7 from its stronger attraction to Regulus (which you may see ~~ex~~ expressed in the 3d Column of single Elective attraction in the 28th Page) unites & ascends with it, while the ☿ & 🜍 which remains behind unite together, & thus form a Cinnabar which is called from this manner of procuring it, Cinnabar ♁, altho' it does not contain a single particle of ♁ in it —

4th Distillation or Sublimation by addition serves to Volatilize a whole mixt. Thus by adding Iron to Sal ammoniac.

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ammoniac, we not only encrease the Volatility of the Salt, but we volatilize the Iron likewise. The Flores Martialis are obtained in this manner. —

5th By addition in Distillation we prevent the Fusion of particular Bodies, & thus favour their Resolution. The Body added here, acts mechanically, merely by dividing the matter on which we intend to operate. — Thus if we add powdered brick Dust, or Clay to nitre we prevent its Fusion & hasten its Resolution. —

6th By Addition we may prevent the intumescence of Bodies, & thereby facilitate the seperation of their parts. Thus for Example Air we know is an ingredient in all bodies, & when set at liberty in Distillation rises in Bubbles, which if the Fluid be viscid collects in such Quantities as to endanger the Vessels or to rush over into the Receiver. This happens in a particular manner in ye Distillation of Amber. It may be prevented by adding a quantity of Sand which by its weight break these bubbles of Air before they arrive to any great Height. —

7th

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7^ly & lastly we use Addition in Distillation in order to regulate the Degrees of Heat. Thus for Example in Distil~~ation~~ling ye essential Oils, we add some water which we know can acquire only a determined Degree of Heat — & thus we prevent an Empireuma from being formed in the Oil. — —

— These are all the Cases of Distillation & sublimation. I thought it necessary to dwell particularly upon them. Notwithstanding they may appear tedious at present, you will find what we have said of them will tend to facilitate your becoming acquainted with the operations of Chemistry — — — —

— — — Before we proceed to speak of the different methods of Distillation & of the Vessels employed in it I shall explain ye meaning of a few Termes. —

— When a matter, obtained by one Distillation, is subjected to a second, that it may be more entirely seperated from matters, which adhere to it in the first, the operation is called Rectification, Dephlegmation & Concentration — — —

— Ardent Spirits part with a considerable quantity

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-tity of water in a second Distillation, & becomes more pure afterwards - hence they are said with some propriety to have undergone a rectification.

The Term Dephlegmation is derived from Phlegm which is a general name for water among the Chemists. It is applied most properly when we evaporate water from any Body which contained it.

Concentration, is when the Parts of any Body which are diffused in any medium are brought close together. This is performed sometimes by means of freezing as well as in Distillation. —

— There is another Term, which comes in proper-ly under this Head, (ie) Cohobation, which is when a matter obtained by one Distillation, is returned a-upon y^e same matter, from which it was drawn be-fore, to be again distilled from it, in order to obtain a stronger Impregnation. This Operation is of two kinds. The first is when the matter is returned upon the subject from whence it was drawn — The 2^d is when y^e matter distilled is returned not upon

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upon the matter from whence it was drawn but upon a fresh portion of the same kind. —

The Form of Chemical Vessels employed in distillation are different according to the manner in which we operate. Distillation is therefore divided into 3 kinds.

(a) per Descensum
(b) per Ascensum
(c) per Latus.

Of each of which we shall

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Having finished the first Part of our Course, we come now to the second general Division of our Course, (i.e.) to treat of the Object of Chemistry

— And here a Question very naturally rises, & that is what order shall we follow in treating of the Objects of Chemistry. — Most of Chemists have divided them into what they call simple or Elementary Bodies. — By these they understand certain Ultimate Principles of Matter; which are simple in themselves & incapable of Divi=sion. Could we arrive at an exact knowledge of these, no Method of arranging the Objects of Chemistry would suit us better. But as we are ignorant of the Number, as well as nature of these Elementary Principles, we cannot pretend to treat of them ~~[illegible]~~ seperately. — Chemists we find differ in their Opinions of what are Elementary Bodies. Thus for Example the German Chemists di=vide them into Salt, Earth, 🜍 & ☿. This Division of the Elementary Bodies arose entirely from their confi=ning their attention too much to Metals. They say nothing

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nothing of Air or Water which are extended much more over the world, & app~~ea~~roach much nearer than Salts or Earth to Elementary Principles, nor have they been able to prove that either of them can be made from any of the four Bodies they mention. —

— The French Chemists have followed another method of aranging the Elimentary Bodies. — They divide them into Air, Earth, Water, & Fire. These we

of y^e french. & for this Reason Macquair begins in his
find are the Eliment~~ary~~s ~~of~~ Chemistry to treat of Salts, which he says are ~~[illegible]~~ composed of two of his Elimentary Bodies, viz: Water & Earth. This account of the Ultimate Principles of Salt is by no means true, for altho' by repeatedly crystalizing & evaporating a Salt, a little Earth may be procured from them, yet we do find any Combination of Earth & Water will produce a a Salt. — They undoubtedly do contain some Earth, but this we believe is foreign to them. What else they contain besides Earth, we cannot pretend to determine. — As to Fire we have no doubt of its being an Elimentary principle, But as we know so little of y^e Nature of it, we cannot pretend to treat it as such.

But

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But as for air – Earth & Water they are by no means Elimentary Bodies. Air we find enters into the Composi=tion of many Bodies, & is likewise produced from them by certain Chemical Operations. Besides this, we have lately been led to see that it is a compound Body, & y^t it is seldom to be met with in a pure Elimentary state. – A state of Composition perhaps is most natural to it. Nor have we any proofs of Earths being an Elimen=tary Body – They all contain more or less foreign Matters in them – even y^e purest kinds of them, such as Crystals, have been supposed to owe their form to Waters being mixed with them – An Ingenious Gent: has en=deavoured to show us in a late Volumn of the Philosophi=cal Transactions, that they likewise contain some salt in them as well as water – Crystallization being pecu=liar (he says) only to bodies which have these matters in them – As for Water we are sure it has nothing Elimentary in its Nature. – Experiments with the Air-pump show us, that it contains a great Quantity of Air in it. But what proves above all things, that it is not an Elimentary Body, is that it yeilds likewise

under

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under certain Chemical operations a large quantity of Earth. Mr Boyle was the first who succeeded in this Experiment. Since his time it has been frequently repeated by Margraaf in Berlin & Mr Godfrey in London. — But supposing these Bodies were ultimate or Elimentary Principles, we could not treat them Chemi=cally, for we know but little about them, or how they act in a seperate state. — We ~~know~~ are sure however these are simple in themselves, & incapable of Divisibili=ty. The Appearance of Nature in her operations fa=vours this Opinion. Animal & Vegitable Substances continue to perish & be renewed again from year to year. The Oak ~~Bark~~ Tree for Instance is the same now that it was formerly, & produces y^e same Leaves — Bark, Juices & Fruits that it did immediately after the Creation. Now if the Ultimate principles of Mat=ter were liable to changes or Division we should see a proportionable Change in the Bodies, which they con=stitute — But this we see is not the Case. — Sir I. Newton illustrates this Opinion by an example taken from the Works of Art. If (says he) an arch

 of

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of a given size be built of Stones properly adapted to each other, it will not be difficult to destroy & again rebuild it, provided the stones remain unchanged. But if the stones by any Means become Altered, either in Shape or Magnitude, it will be impossible to produce an Arch of the same size with the former, out of the same Materials. – This Argument when pursued a little further might be of use to the Theologist in proving y Resurrection of the same Body after Death, for if some bodies do consist of certain Elimentary parts, such as the seeds of Trees, & the like, why may we not suppose the same to take place in the human body? A late French Writer has proposed something new upon this subject. He imagines that there is a substance in the brain Analogous to the seed of a Plant in which all y Parts of the human Body are contained in Embrio. This substance he says is incapable of Corruption, & at a proper time will extend itself in such a manner as to produce a body exactly y same as that which it came from. This opinion however ingenious is exten=
=ding the

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the Analogy of Plants too far. I would rather suppose that the ultimate particles of the same body will be reunited at the Resurrection. The Example we mentioned produced by Sr. I. Newton seems to favour this conjecture. perhaps some such change will be produced upon us as Metals undergo when they are reduced or brot back again from a calcined to a Metallic state. A Calx of lead has no resemblance to lead itself. Its particles look like Earth, & have many of the properties of it. But by adding to it a little tallow, or Charcoal, or any thing, which contains the principle of Inflammation in it, we immediately ~~[illegible]~~ collect all these Particles together into one Mass, & they again put on ye Form, & recover all the properties of Lead. But to return.

All the Objects of Chemistry may be divided into what the Chemists call Elements or Mixts.

Elements or Atoms we have said, are the minute Particles ~~together~~ of Matter, which are no ways changeable or divisible by any Powers of Art. — They are not objects of our senses, & therefore cannot be objects of Chemistry.

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Chemistry in their seperate State.

<u>Mixts</u> are said to be composed of Elements. They are the most simple Bodies we are acquainted with. Thus Earth may be called a <u>Mixt</u>. It is composed of Water, Air, & Salt. In like manner <u>Water</u> is a <u>mixt</u>, as being composed of a fluid Matter, Air, & Earth.

Here it may not be improper to explain several other Chemical Termes. Bodies are further said to be <u>Aggregates</u>. These consist of what are called ye Integrant Particles, which continue the same let them be ever so much divided. The Constituent Parts of a Body are those, on which its Chemical Properties depend. Thus an 7 & an α are the constituent parts of common Salt, as it is by a combination of these two that a Neu=tral Salt is formed. You see from this, that common Salt may be looked upon both as an Aggregate & mixt. The Resolution of the latter employes a Chemical; & the Division of the ~~latter from~~ former a Mechanical operation. —

— Having mentioned the Difficulties which occur

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occur in finding out, & arranging the Elimentary Prin=
=ciples of Bodies, I shall not attempt it in ye present
Case, but shall confine myself entirely to the History of
the Chemical Properties of Bodies as they are presented
to us by Nature. In order to do this in as systematic a
Method as possible, I shall divide the objects of Chemistry
into the five following Classes.

1st Salts.–
2d Earths–
3d Inflammables–
4th Metals.–
5th Waters.–
6 Airs

When we have finished these we shall deliver the Che=
=mical History of Vegetables & Animal Substances. Un=
=der these we shall include all the simple Products of
Nature, so that at the end of our Course we shall be
able to tell the Composition & Analysis of every thing
in the World which comes under ye Notice of our senses or
Experiments. – A great Undertaking this. The Execu=
=tion of which ~~appears~~ altho attended with many diffi=
=culties on

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on both sides will notwithstanding afford us much Entertainment & insight into the Mysteries of Nature — But before we proceed any further, give me leave to observe that the greatest part of Chemical knowledge consists in a knowledge of Chemical Facts — Upon this account you will find it necessary to use your memories as much as possible in the Course of these Lectures. It will not be sufficient for you to get what are called good Notes. These are apt to deceive the young Student. for in trusting to them, he too often neglects to treasure up what he hears in his memory, by which means at the End of a year or two he finds his notes as new to him as they were when he wrote them. No man I believe ever forgot any thing he learned perfectly. It is owing to our learning things so much by halves, that we forget them so often. By frequently revising your Notes, by talking & thinking often upon what you hear, you will impress ye Facts which Chemistry affords, so deeply in your minds that you will never forget them. But to return.

You will easily see from our Division of the Objects of Chemistry that it is in some measure an

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<u>Artificial</u> one. You are not to expect that Salt, ~~&~~
Earths, & the like are always produced by nature, in
that state of simplicity which Chemists are obliged
to consider them. No - Salts are often combined with
Earths, with Inflammables, Metals & Water. - Earths
are again combined with Inflammables, & so on of all ye
rest. - We shall however treat of them <u>seperately</u>, for
they are alike objects of Chemistry, whether they are
produced by Nature, or formed by the hands of art.
After this we shall treat of them in a compounded state -
I mentioned this that we may be more precise in our
Definitions of those Bodies - We must suppose them
to be simple, or our Definition will be liable to many
Exceptions.

Of Salts. -

<u>Salts</u> are those substances which are ~~fixt~~ fusible & soluble,
not Inflammable, & give a sense of Taste to the Tongue.
I am well aware of this definitions being faulty in
two ~~place~~ Particulars. In the first Place we have
Characterized them by one negative Quality (i.e) by not
<u>being Inflammable</u> - it being a Rule among <u>Logicians</u>

never

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never to make Definitions consist of any thing but positive Qualities. & in the 2d. place. the want of Inflammation does not belong to all the Salts. — Notwithstanding those Objections against our Definition we are obliged to admit the 1st in order to destinguish y Salt from Inflammable Bodies. & as to the 2d we cannot admit of its being a solid Objection in as much as such of the Salts as are Inflammable are not to be looked upon as simple, but as mixed with a quantity of Inflammable Matter. —

— Let us attend to the properties which are common to Salt. —

In y 1. Place they are white — semitransparent, & brittle in their simple state. —

2d. They become fluid by means of Heat, & are easily converted into Vapor. Some require a great Degree of Heat to convert them into Vapor. While others evaporate in the Heat of y common Air. —

3dly They are all soluble in Water — Water is so universal a menstruum for Salts, that it is doubtful whether any other Bodies can dissolve Salts, but in

Proportion

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Proportion to the Water they contain. Some of the Salts attract Water so powerfully that they dissolve in y^e open Air. This is called Dilaquescence — As the solubility of Salts in water is the prin=ciple mark which characterizes them, we shall point out those Circumstances which take place in their Solution.

1st In the Solution of Salts in water there is an Extrication of Air. This often gives the Water a turbid appearance for some time, which has been taken by some Persons not well acquainted with Chemis=try for a mark of a Waters containing some mine=ral in it. —

2dly In the Solution of Salts in Water there is a Generation of Heat or Cold. All those Salts which are properly called Chrystalline generate Cold — those which are called Dilaquescent such as Regenerated 🜿, Salt of 🜿 & the like generate heat. — Whether a true Chemical Mixture, or only a simple Solution, takes place in this latter Case, we cannot pretend

to

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to determine. It is most probable a Chemical Mixture. —

3.^dly^ The more salt is dissolved in water, the more slowly any further addition of it will be dissolved. — When Water will dissolve no more salt it is said to be saturated. —

4.^thly^ Salts differ in their Degree of Solubility, so that it is impossible to tell y^e^ exact proportion that may be dissolved in a given Quantity of Water, in as much as the salts are so very unsteady in their Characters. In general we may observe that water dissolves more or less salt, according as it is differently heated. This holds good with regard to all the salts except one, (i.e.) common salt — Cold & hot water dissolving an equal quantity of it. It is therefore a little surprising that Dr. Boerhaave should have chosen this salt above all others to illustrate this remark upon Solution. — What tends so much to make the salts unsteady in their Characters

with

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with regard to their solubility in Water, is that ~~proportion to~~ the Quantity of Salt soluble in water is in proportion to the Quantity of Air the water contains. — This you will easily conceive when you recollect ~~where you recollect~~ the Fact we mentioned formerly of a saturated Solution of Nitre depositing some of the Nitre when placed in an air-pump. From this we may conclude that water when it is deprived of some of its Air by Fire, does not dissolve so much of the Salt ~~&~~ as we might expect from the Degrees of heat it contains when boiling. But notwithstanding these difficulties in determining the different degrees of Solubility in salts, the Chemists have found out that in general they dissolve in the following Order. —

1st Vegetable Alkali. — 2d Regenerated ~~&~~ 🜿 — Glauber's Salt — Sal Digestivum — common Salt — common Ammoniac — common Nitre — Cubic Nitre — Fossil Alkali — & lastly 🜿 Vitriolatum

As for the few Neutral salts which remain, no accurate experiments have as yet been made

upon

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upon them with respect to their solubility in wa=
=ter.

5thly When Water has been fully saturated with any salt, it will dissolve a greater Quanti=
=ty of it, if we add another neutral salt to it. Thus a saturated Solution of Nitre, may be made to dissolve more Nitre, by adding a little common salt to it. In like manner 10 or 12 grains of Cor=
rosive Sublimate may be dissolved in an ounce of Water, But if we add a few grains of Sal Am=
=moniac to it, it will dissolve 4 times that Quan=
=tity of the sublimate. This ~~ear~~ curious fact has long been a matter of surprise to the Chemists. It depends probably upon a fresh Portion of Water be-
-ing introduced in the common Salt & sal ammoni-
=ac which are added to the solution of the Nitre, & Corrosive Sublimate.

6ly When Salt is dissolved in Water, it causes y Water to occupy sometimes more, but frequently less space than it did before. The Reason of this Fact might afford us some speculation, but we

shall

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shall not enter upon it at present.—

These are all the remarkable Circumstances which attend the solution of Salts in Water.— We shall next proceed to treat of the method of seperating Salts from Water. This is done by —— 1st Evaporation

2d By Precipitation

3d By Chrystalization. of each of which we shall treat at our next Lecture.—

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Evaporation is never employed except in proeu-
-ving those Salts which are incapable of being
Chrystalized, upon the account of their being so
apt to be decomposed, or to contract an Empireu-
-ma after all their Water is dissipated from them.
In those Cases where we are obliged to employ
Evaporation in obtaining salts, the heat used in
evaporating the Water should be as gentle as pos-
-sible. The Heat of the Sun is generally sufficient
for this purpose. Bay Salt is obtained in this
manner & to this it owes its great superiority both
in its beauty & Antiseptic Qualities to that which
is obtained in y^e ordinary way by boiling. –

Precipitation is sometimes used in obtaining
Salts from their Menstrua – Thus by adding ▽
to a solution of Epsom Salt in Water – the salt is
immediately precipitated. In like manner by
adding a dry fixt Alkali, to a solution of any of y^e
Neutral Salts in Water, the salts will fall to y^e
(617) Bottom. This is owing to the strong attraction
which

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which the Alkali has to ~~Wa~~ Water, which causes it to attract from the Neutral Salts. Acids like=
=wise precipitate Neutral Salts from Water -
- Thus if we add ⊕▽ to a Solution of Glauber Salt, the Salts will be precipitated immediately - This as in the former Case is occasioned by a double Elective Attraction; (i.e.) by the Water being attracted more strongly by the ⊕▽ than by the Glauber Salt. This Method of obtaining Salts by precipitation, would perhaps be more in use, was it not for the next me=
=thod we spoke of. Viz:-

Chrystalization. This is most generally em=
=ployed in seperating Salts from their Solutions in Water. The Water is evaporated till a Pellicle ap=
=pears on the Surface - After this it is put into a cool Cellar, or some quiet place, where it will not be exposed to the least Motion of any kind. There are some Salts however ~~which~~ never afford this Pellicle - of this Number is Nitre. In order to know when this Salt is evaporated we must take a few drops of it out of the Vessel where it is boi=
ling &

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& pour them upon a piece of Glass – If they re-
-main we may ~~conclude~~ continue the Evaporation
but if they become solid & hard immediately, we may
take off the whole & suffer it to Chrystalize.. –

The Liquor should not be cooled too sudenly ~~or~~ or
the Nitre will calcine instead of Cristalizing.

Cristalization is employed not only for seperating
Salts from their solution in water, but for sepera-
-ting one salt from another. This is done by finding
out the disparity in the size & figure of Salts or a
Disparity in their solubility in Water. Thus for exa-
-ample a Quantity of Water, that in ye common
Temperature of the Air, dissolves 3 parts of common
Salt, will dissolve 6 parts of Nitre. ~~While its power~~
~~of dissolving~~ But if this water is made to boil it
will dissolve 10 times the Quantities of Nitre, while
its power of dissolving common salt continues
pretty nearly ye same. Perhaps the fresh quan-
-tity of Water conveyed into the given Quantity by
the addition of the Nitre may cause it to dissolve
a few grains more of the common salt – From
this

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this it is evident that if we evaporate the liquor properly, a large quantity of common Salt will be crystalized, while all y Nitre will remain suspended, so that by repeated evaporations with y addition of fresh water, we may seperate these two salts very accurately. It is in this manner (as we shall say hereafter) that Nitre is purefied from common Salt — The Fossil Alkali is likewise seperated in this manner from the common salt which is apt to adhere to it. —

— Crystals of Salt contain a considerable quantity of Water in their Composition. — Glauber Salt contains 3/4 — Nitre — 1/2 — & vitriolated ♁ something less. This Water may be dissipated from them, but not without destroying their Crystaline structure. It may be again restored to them by the addition of a fresh Quantity of Water. —

Crystals of Salts contain likewise a small Quantity of Air — This we prove not only from

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our

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~~from~~ our being able to dissipate Air from them, but from the absolute necessity of Air having free access to them, when they are put aside to crystalize. — a single experiment proves this. If a super=saturated Solution of Nitre, be closely confined while hot in a proper Vessel, the Liquor will re=main fluid as long as we please, But no sooner is the external Air admitted, than the superfluous quantity of Salt, which the hot water suspended, will immediately subside in the Form of Crystals.

It is worthy of Notice here that almost every kind of Salt has a kind of Crystal which is pecu=liar to itself. Some of them are of a prismatic — others of a Cubic — Others of a Rhomboidal & others of a hexagonal Form. But this Form in the Crystals of Salts, is far from being so steady as to enable us to distinguish them from each other by it. — Thus two Crystals of the same salt by uniting together often puzzle us, & make us

suspect

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suspect some new Salt. — The method of crysta:
:lizing them likewise alters their Form conside:
:rably, & tends to encrease the Difficulty of deter:
:mining what Salts they are by this Mark. —

— I shall not attempt here to explain the Cause of the Crystalization of Salts. I acknow:
:ledge myself ignorant of it. — It is one of those secret operations of Nature, which tho' it appears very simple has confounded some of the greatest Geniusses, & baffled the Enquiries of the great Sir Isaac Newton himself. — —

— Before we enter into a particular detail of y Salts, I shall here explain the meaning of one or two Chemical Termes. —

— When a Salt by standing for sometime in the open Air, falls down into a fine Powder it is said to undergo a Spontaneous Calcination. — When a Salt is thrown into the Fire, it general:
:ly goes off with a little Explosion. This is called Decripitation. It is occasioned by y Water in the Salt being suddenly converted into Vapor. —

Having

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Having now finished our account of the general Properties of Salts, we shall next proceed to speak of their particular kinds. —

— Salts are divided into simple & compound —

— The simple Salts are again divided into acid & Alkaline. —

— The Acid salts are divided into Mineral, Vegetable & Animal. —

The Mineral Acids are subdivided into ⊕>, ⦶> & ⊖> — & 1st we shall begin by treating of those properties which are common to the Mineral acids in general —

1st They are all obtained in a fluid form. M: Hellot indeed tells us, that in pursuing the Distillation of green Vitriol to a great height, towards ye close of the operation, a concentrated ⊕> came over in a solid crystalized Form. But this seldom happens nor can we procure it even in those Cases where we most wish for it. A state of Fluidity is therefore ye most natural to them.

A 2d general Property of these Salts, is that they have a strong attraction to water, in so much that they attract from the Air itself —

3dly

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3dly They all produce Cold when mixed with Ice — & same heat when mixed with water —

4thly They change the syrup of Violets, or an Infusion of any of ye purple Flowers to a red color.

5thly They all unite with the Alkaline salts, ~~without~~ producing a violent Emmotion; which we call Effervescence. This Effervescence however, is by no means a mark of an Acids meeting with an Alkali; for an Effervescence of ye same kind, takes place between Acids & metallic substances —

— 6thly They are extreemly corrosive & easily act upon Animal & Earthy substances when they are in their concentrated state. But when they are diluted with Water, they loose their acrimony & are very usefull in Medicine as well as in several of the Arts. —

— 7ly & lastly they all impart what is called a sower taste to the Tongue. This Property is so common to them, that their very name is derived from it. —

(22) These are all the Properties which the

Mineral

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Mineral Acids possess in common, we shall make Notice of ye distinguishing properties of each of them & 1st

Of the ⊕ —

This Salt is a pure, native substance, altho' it has never been discovered in a simple state; It is found frequently combined with alcaline Salts — with Inflammables — with Earth — & above all, with some of the Metals; particularly with <u>Iron</u> — When this is ye Case it is called <u>Vitriol</u>, & hence its Name of <u>Vitriolic</u> is derived. —

When ~~this~~ it is pure, it is colourless & transparent. Its Specific Gravity is very great being to Water as 10 is to 19. — It is so very dense, that many suppose it to be of an oily Nature — — Hence it is often called ye oil of Vitriol — But upon Tryal we find that it is no ways inflammable, nor has it any of ye other properties of Oils. It feels oily indeed between our fingers, but this is owing to its attracting powerfully

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& dissolving that unctuous substance, which gene-
-rally covers all parts of the body, but particularly
the ends of the Fingers. —

— Heat produces no remarkable Change upon
ye ⊕7. It requires several hundred Degrees of heat
to make it boil or evaporate. —

— The Effects of Mixture upon ye ⊕7 are more
remarkable. We shall briefly point out its Rela-
-tion to all ye Objects of Chemistry as they stand
Classed in our Syllabus. —

1.st ⊕7 unites with the other two mineral acid
as also with the Vegetable & Animal & produces
in uniting with them some heat. — We cannot
pretend to say whether this is occasioned by its
union with the pure Acid, or with the water
~~with~~ which all these acids generally contain —
— It is certain a third substance is often produ-
-ced from such Combinations which possess ye
properties of neither. — A striking Instance
we have of this in the Nitrous & Muriatic
7s which do not act upon ☉ in their seperate
state

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State, but readily dissolve it when they are uni-
-ted in what is called Aqua Regia. —
— 2d. The ⊕> unites with all the alkaline salts
producing Effervescence & Heat— There is we
grant a certain state of Alkaline salts in which
the addition of ⊕> is attended with no Effervescence
— This is owing to the Alkaline salts being de-
-prived of their fixed Air, & it is upon y^e Escape of
this, that Effervescence between an Acid & an
Alkali depends. But of this we shall say more
hereafter when we come to treat of particular-
-ly of fixed Air. —
— From a Combination of ⊕> with α a neu-
-tral or compound salt is formed which possesses
none of the properties of either of the two simple
Salts. This Neutral salt will be different ac-
cording to the species of α with which the ⊕> is
united, you may see an account of them in y^e
Table of Neutral salts in y^e 10th page of y^e Sylla-
-bus— Thus with the Fossil Alkali it forms
Glauber Salt— with the Vegetable α— Vitrio-
-lic ☐ & with &c Vitriolic Ammoniac —

It.

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~~It attracts~~ It attracts the Alkalies more powerfully, than any of the other Acids, & in Consequence of this property we may decompose all the Neutral Salts in y Table. Upon this account it is placed first in the Table. The other Acids are placed in the Order in which they attract y Alcalies & denote the greater or lesser Degree of Facillity ~~by~~ with which they are decomposed by ⊕7. —

— 3ly The ⊕7 unites readily with most of the Earths — with y calcareous Earth it forms a substance called selinites, with common clay it forms alum, with Earth of Magnesia, it forms Epsom Salt.

4ly the ⊕7 has a strong attraction to y △. — Its superior attraction to it above every thing else, may be seen in y first Column of y Table of ~~Compound~~ Single Elective Attraction. —

— So strongly does it attract it, that unless we confine y Veal very closely which contains it, it will be drawn in from the Air. — The dark Color which we so often observe in the ⊕7 is not

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not Natural to it — It is occasioned by its having attracted & dissolved some matters from ye Air which contained the △. The ⊕ may again be rendered transparent & colorless by <u>boiling</u>, for the Diet, or inflammable matter is thus either burnt, or dissipated with the Vapor, which rises during the time of its boiling.

When the ⊕ is combined with the pure △ it forms a <u>Sulphur</u>. That 🜍 is composed of Nothing but ⊕ & △ may be proved from
33. many Experiments. —

It yields nothing but these two Principles in all our Operations upon it. There is not in all Chemistry an Instance of a greater change produced in Bodies by Mixture than in 🜍. The ⊕ & △ are extremely active in their seperate States. — But when they are united they lose most of the Qualities which were peculiar to each, in somuch that they may be taken into the body in large Quantities with the utmost safety. — The Properties of Bodies are altered by mixture in proportion to the slowness with which they combine. — The Union therefore of the ⊕

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⊕ & △ in 🜍 must reach beyond our Conseptions —

— If ⊕ is added to the oil of Olives it unites with it, & produces a dark thick Substance resem=bling Tar. This substance when subjected to a Dis=tillation yeilds a true 🜍. But if it is added to the oil of Turpentine it rushes towards it with great Violence & Impetuosity, producing a considera-ble Heat & Ebullition, & causes it to send forth ~~the~~ a great deal of Fumes. —

— The ⊕ unites with ardent spirits, produc=ing with them the Spiritus Vitrioli Dulcis & the Vitriolic Æther. —

5ly It unites with all the Metals except ☉. — It will not unite with Iron or Zink, unless it is diluted with Water. — It must be highly concen=trated in order to dissolve Copper. All the Other Metals require not only a concentrated Acid to Dissolve them, but the Assistance of a boiling heat likewise. —

6ly The ⊕ has a strong attraction for water, insomuch that if ʒiij of it are exposed to y^e air it will attract ʒj of Water from it in 24 Hours

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Hours. There is always a generation of a good deal of Heat when it is mixed with water. – The Water afterwards standing sometime becomes of a milky Colour, & drops a white Earthy sediment. This sediment is composed of a calcareous Earth united to ⊕7, which is called Selinites. – If the mixture of ⊕7 & water is boiled, it ~~dispositit~~ deposites a much larger ~~sediment~~ Quantity of this sediment. —

— Notwithstanding y Generation of Heat is so remarkable in the Union of ⊕7 & water, yet the reverse of this takes place from mixing ⊕7 & Ice together. There is a very great generation of Cold. The Reason of this is Plain. In the former Case a true chemical Mixture is produced – in the latter nothing but a solution takes place – The one you know is always attended with a generation of Heat – the other of Cold. —

7thly The ⊕7 unites with all Vegetable & animal substances & dissolves them. They contract a black color from their Union with the ⊕7

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in proportion to the Quantity of $\triangle$ they contain: With this we finish our account of the Proper=ties of ~~Body~~ $\oplus$, we shall next proceed to treat of its Origin or in other Words of its Natural His=to=ry. — —

End of the first Volumn —

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